

# Bothalia

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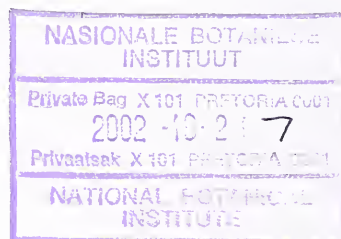
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# Systematics of the genus *Daubenia* (Hyacinthaceae: Massonieae)

J.C. MANNING\* and A.M. VAN DER MERWE\*\*

**Keywords:** *Amphisiphon* W.F.Barker, *Androsiphon* Schltr., *Daubenia* Lindl., Hyacinthaceae, Massonieae Baker, *Neobakeria* Schltr., South Africa, taxonomy

### ABSTRACT

*Daubenia* Lindl. was until recently thought to comprise the single species *D. aurea* Lindl. but is now considered to include the monotypic genera *Androsiphon* Schltr. and *Amphisiphon* W.F.Barker, as well as the species previously referred to the genus *Neobakeria* Schltr. Eight species are now recognized in the genus, including the new combinations *Daubenia comata* (Burch. ex Baker) J.C.Manning & A.M.van der Merwe and *D. zeyheri* (Kunth) J.C.Manning & A.M.van der Merwe. Each species is fully described and illustrated in black-and-white and in colour. A key to the species, and distribution maps are provided.

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### INTRODUCTION

The Hyacinthaceae (excluding the North American chlorogaloid genera) are now well established as a monophyletic lineage within the order Asparagales (Fay & Chase 1996; Pfosser & Speta 1999; Fay *et al.* 2000). The family is distributed through Africa, across most of Europe and central Asia to India, and in Andean South America, with centres of diversity in southern Africa and the Mediterranean (Speta 1998). The plants prefer open,

sunny habitats in seasonal climates and are correspondingly rare in heavily wooded, tropical regions. Although it has long proved difficult to devise a natural infrafamilial classification of the Hyacinthaceae, recent molecular analysis of the chloroplast DNA region *trnL-F* provides strong support for the division of the family into four subfamilies, Oziroëoideae, Urgineoideae, Ornithogaloideae and Hyacinthoideae (Pfosser & Speta 1999). Within the subfamily Hyacinthoideae two clades are retrieved. The first combines the Indian and African genera south of the Sahara, and largely coincides with the delimitation of the tribe Massonieae Baker (with the significant inclusion of the sub-Saharan species previously placed in the genus *Scilla* L.). The second clade includes the Mediterranean and Asian genera, corresponding to the tribe Hyacintheae Dumort (Pfosser & Speta 1999). Despite the strong molecular support for the recognition of these two tribes, few corroborative morphological characters are available. Further division of tribe Massonieae into the subtribes Ledebouriinae and Massoniinae (Müller-Doblies & Müller-Doblies 1997) is not supported by the molecular data. The poor congruence between morphological and other characters within Hyacinthaceae has also made generic circumscriptions very difficult. One of the consequences of this has been the recognition of a large number of genera that are poorly defined morphologically (Speta 1998).

Within the tribe Massonieae the relationships between the species traditionally placed in the genera *Amphisiphon* W.F.Barker (1 sp.), *Androsiphon* Schltr. (1 sp.), *Daubenia* Lindl. (1 sp.), *Neobakeria* Schltr. (1–3 spp.) and *Massonia* Houtt. ( $\pm$  6 spp.) have been especially controversial (Jessop 1976; Müller-Doblies & Müller-Doblies 1997; Goldblatt & Manning 2000). These genera share some morphological characters, in particular two prostrate or spreading leaves and a condensed inflorescence of more or less tubular flowers but differ greatly from one another in floral details. Traditional morphological methods have not been useful in resolving the relationships between the species but molecular analysis has proven extremely informative. Analysis of chloroplast DNA (Van der Merwe *et al.* in prep.) includes *Amphisiphon*, *Androsiphon*, *Daubenia*, *Neobakeria* and one species of *Massonia* in a strongly supported monophyletic clade. This clade is resistant to further segregation at the generic level and the cir-

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PLATE 1.—A, *Daubenya comata*; B, *D. namaquensis*; C, *D. marginata*; D, *D. zeyheri*; E, *D. alba*; F, *D. capensis*; G, *D. srylosa*; H, *D. aurea*. Photographer: John Manning.



cumscription of the genus *Daubenya* is therefore broadened to circumscribe the whole clade. The genus *Daubenya* in this broader sense is characterized by a tunicated bulb with the older tunics leathery and dark brown and extending as a short papery neck, two  $\pm$  glossy leaves with impressed longitudinal striations on the upper surface, and a racemose, corymbose or subspicate inflorescence of white, red or yellow flowers with a slender, cylindrical perianth tube. Species of *Massonia* s. str. are characterized by their soft, fleshy leaves, corymbose inflorescences with large, leaflike bracts, white to pink flowers with the tepals typically sharply recurved from the base and then incurved in a characteristic sigmoid fold, and tumbleweed-like infructescences.

*Daubenya* is centred along the western edge of the southern African central plateau and all of the species are winter-growing. Most are highly localized endemics restricted to pockets of doleritic clays. The vegetative similarity between the species contrasts sharply with the unusual diversity of floral form evident in the genus. This floral radiation represents adaptations to a variety of pollinating agents, including insects such as bees, butterflies, moths and monkey beetles and sunbirds. Most of the species exhibit adaptations to anemochory, especially in the development of large, winged capsules. These winged, dehiscent capsules contrast markedly with the indehiscent, ovoid capsules present in two of the species. Eight species are recognized within this expanded concept of *Daubenya*, some of them well established in horticulture but others very poorly known. This revision provides full descriptions of all species as well as notes on their history, ecology and distribution. All of the species were studied in the field and each is fully illustrated in black-and-white and in colour.

#### MATERIALS AND METHODS

Herbarium specimens in BOL, K, NBG, PRE and SAM were studied to gather data on morphology, flowering time and distribution. Extensive fieldwork was also undertaken and all species were visited in their natural habitat. All observations on pollinators were made in the field. Conservation status for each species was assessed according to the new IUCN categories and criteria (Victor 2000).

#### MORPHOLOGICAL CHARACTERS OF TAXONOMIC SIGNIFICANCE

**Bulb:** the bulbs in *Daubenya* are turbinate to globose or ovoid in shape and between 20–35 mm diam. The outer tunics become leathery and dark brown on drying, and split at the top into narrow, flat, papery segments that form a characteristic neck. This papery neck is particularly conspicuous in species or individuals with deeply buried bulbs. A similar neck is found in some species of *Lachenalia* but not in any species of *Massonia* s. str.

**Leaves:** all species have paired leaves that are prostrate or spreading. The leaf bases are subterranean and long or short depending on the depth of the bulb. The blades are glabrous and rather glossy above with impressed longitudinal striations along the main veins.

They are lanceolate to ovate in shape and measure 40–150  $\times$  25–50 mm.

**Leaf anatomy:** leaves in *Daubenya* are amphistomatic with a thick cuticle. The marginal epidermal cells are columnar with slightly thickened walls and a unicellular hypodermis is present at the leaf margin. The mesophyll typically comprises three rows of palisade parenchyma adaxially and three rows of spongy parenchyma abaxially. The vascular bundles are surrounded by parenchymatous bundle sheaths. Slight indentations correlating with the impressed longitudinal striations on the upper leaf surface occur above the main veins. In these indentations the epidermal cells are smaller than elsewhere with thicker outer periclinal walls and they overlie two rows of palisade parenchyma instead of three.

**Inflorescence:** is borne at ground level between the leaves on a subterranean peduncle. It is essentially racemose but varies in shape from conical to capitate. Shortening of the rachis in several species results in a corymbose, rather capitate inflorescence, whereas suppression of the pedicels results in a subsPICATE inflorescence, accompanied in some species by shortening of the axis. Well-developed pedicels and a corymbose inflorescence are found in *Daubenya aurea*, *D. alba*, *D. capensis* and *D. zeyheri* but the remaining species are characterized by a subsPICATE inflorescence. This is usually conical, protruding for up to 90 mm above the leaves in *D. marginata* and *D. namaquensis*, but is  $\pm$  capitate in *D. comata* and *D. stylosa*. The inflorescence bracts are usually inconspicuous and pale in colour except in *D. aurea*, which is characterized by large, green bracts. The bracts typically increase in size acropetally but the degree of this increase varies. In *D. comata*, *D. stylosa* and *D. zeyheri* the upper bracts are only slightly larger than the lower ones and form an inconspicuous greenish coma at the top of the inflorescence. In *D. namaquensis* and *D. marginata*, however, the increase in bract size is marked and the inflorescences are topped by a more conspicuous coma of greenish or pinkish to orange bracts. The inflorescence remains at ground level until the fruits are mature, at which stage the peduncle elongates rapidly from the base, pushing the infructescence well above the ground as a prelude to dispersal of the seeds.

**Flowers:** there is great variation in the morphology of the flowers in *Daubenya* but all species are characterized by a slender, cylindrical perianth tube. The tepals are usually free and spreading from the level of the stamen insertion but in *D. stylosa* they are fused well beyond this level into a narrow tube around the staminal column. Tepal colour ranges from white or pinkish in *D. alba*, *D. comata*, *D. marginata* and *D. zeyheri*, to bright yellow in *D. capensis*, *D. namaquensis* and *D. stylosa*, or brilliant red in most populations of *D. aurea*. The flowers in most species are actinomorphic but some degree of zygomorphy is evident in the lowermost flowers in *D. comata* and *D. namaquensis*, and reaches an extreme degree in *D. aurea*. In *D. comata* and *D. namaquensis* the outer flowers are at most weakly bilabiate through a slight asymmetry in the perianth tube, with the adaxial side slightly longer than the abaxial side. An analogous situation is also sometimes evident in the filament column in the lowermost flowers of *D. alba*. In *D. aurea*, however, the

zygomorphy is extremely marked and results from the great enlargement of the lowermost tepals of the lower flowers, accompanied by an elongation of the perianth tube on this side rather than on the adaxial side. The stamens in most species of *Daubenya* are  $\pm$  fused at the base into a staminal column or tube. This is most marked in *D. alba*, *D. aurea*, *D. capensis* and *D. stylosa*. In the bilabiate, lower flowers of *D. aurea*, the abaxial tepals are actually fused to the staminal column and as a consequence of this the abaxial filaments are inserted much higher up the perianth than the adaxial and appear to be free from one another. In *D. capensis* a thick, convex disc occludes the top of the staminal tube with the style protruding through a small pore in the disc. The staminal column is very short in *D. marginata* and *D. zeyheri*, and is lacking or only slightly evident in *D. comata* and *D. namaquensis*.

**Fruit and seeds:** the fruit in *Daubenya* is a papery capsule, typically dehiscent loculicidally in the upper portion. In *D. comata* the capsule is obovoid and rounded but in most of the other species it is  $\pm$  inflated and three-angled. These angles are particularly well developed in the upper part of the capsules in *D. alba* and *D. capensis*, and the capsules in these two species are decidedly cuneate in shape. The species *D. marginata*, *D. namaquensis* and *D. zeyheri* are distinctive in their deciduous capsules that fall free of the pedicels at maturity and are dispersed individually. In other species of *Daubenya* the capsules remain attached to the pedicel and rachis and the entire infructescence functions as the dispersal unit. Unique capsules with a persistent, horn-like style characterize *D. stylosa*. The capsules in this species are essentially indehiscent although the locules eventually separate along the septa. The seeds in all species are globose and black in colour with a smooth testa. They range in size from 2–3 mm diam.

#### DISTRIBUTION AND ECOLOGY

*Daubenya* is a small genus of eight species that is endemic to South Africa. It is largely restricted to the fringes of the winter rainfall region along the Bokkeveld and Roggeveld Escarpments, which mark the western margin of the South African central plateau. Five of the eight species occur here, at altitudes of 1 000–1 500 m. Most of the species of *Daubenya* are highly local endemics and only *D. comata* is more widespread, occurring over much of the South African central plateau. All of the species are winter-growing, despite the fact that not all are restricted to the winter rainfall region. Plants typically leaf and flower in the autumn or winter, between April and July, with only one species, *D. aurea*, flowering in the spring, in early September. Five of the species, *D. alba*, *D. aurea*, *D. capensis*, *D. stylosa* and *D. zeyheri* are restricted to the winter rainfall region and respond largely to frontal rain that falls between April and August. Apart from *D. zeyheri*, which is a coastal species confined to calcareous sands near Saldanha, the remaining four winter rainfall species occur along the edge of the Bokkeveld and Roggeveld Escarpments from Nieuwoudtville and Calvinia in the north southwards to Sutherland. The remaining three species occur partially or wholly within the summer rainfall region. *Daubenya*

*marginata* is distributed along the Roggeveld Escarpment but extends inland to Fraserburg, where it enters the summer rainfall region; *D. namaquensis* occurs at the edge of the summer rainfall region in Bushmanland, east of Springbok; and *D. comata* is widespread across the central parts of the summer rainfall region. Despite their distribution, these three species respond to autumn thundershowers and begin to grow slightly before the winter rainfall species.

Most species of *Daubenya* are highly localized endemics known only from a few populations. They typically occur in small colonies, sometimes in large numbers, in heavy clay soils, and are invariably restricted to low-lying washes or drainage lines where the soil becomes seasonally waterlogged. The majority of the species occur on the South African central plateau, where they are largely restricted to clays derived from dolerite. The particular nature of doleritic clays ensures that these soils retain moisture for longer than the surrounding clays derived from shales of the Karoo series. The two remaining species occur on more sandy substrates, *D. namaquensis* in deep red sands and *D. zeyheri* in calcareous coastal sands.

All of the species of *Daubenya* are vulnerable to disturbance or transformation of their habitat, particularly through agriculture. Although predation of the bulbs by porcupines is common among the species growing on the Roggeveld Escarpment, its impact on the populations is unknown. The numbers of these rodents can be expected to have increased as a result of the reduction in their natural predators, particularly leopard. Most species of *Daubenya* still appear to set large quantities of seed in the wild to replace the adult plants consumed by herbivores. An additional pressure on populations comes from sheep and baboon, which eat the leaves and inflorescences, resulting in a drastic reduction in seed set in some instances. A recent initiative aims at the protection of a population of the yellow-flowered form of *D. aurea* from overgrazing through co-operation of the landowner and the local bulb growers' association. There is, however, no formal conservation of this population and its survival thus remains uncertain. In another encouraging development, cultivated bulbs of *D. aurea* have become available in commercial nurseries. All of the species of *Daubenya* are worth cultivating for their compact habit and brilliantly coloured, often fragrant flowers.

#### POLLINATION AND SEED DISPERSAL

The floral diversity evident in the genus *Daubenya* is exceptional in the family Hyacinthaceae and reflects a corresponding diversity in pollination strategies. These include several strategies that, although well developed in the Western Cape, are rare or absent elsewhere. Most of the species produce fragrant, white or yellow flowers that are visited for nectar or pollen by a variety of diurnal and nocturnal insects, including pollen- and nectar-collecting bees, butterflies and moths in the family Noctuidae. The species with generalist flowers include *D. namaquensis*, *D. comata*, *D. alba* and *D. stylosa*. In these species the nectar collects either in the perianth tube only or also in the staminal tube above this. Both the



perianth and staminal tubes are narrow and the nectar is thus accessible only to long-tongued insects.

Two species, *D. marginata* and *D. zeyheri*, are adapted to pollination by sunbirds. The adaptations to ornithophily in these species include a reduced and widened staminal tube that forms a shallow reservoir in which significant quantities of nectar accumulates, orange or red filaments (with purple bases in *D. zeyheri*) and a lack of fragrance. Ornithophily occurs in several other genera of Hyacinthaceae in the Western Cape, especially *Lachenalia* and *Veltheimia*. *Daubenya aurea* is adapted to pollination by monkey beetles (Scarabidae-Rutellinae), a pollination strategy that appears to be unique among the Hyacinthaceae, although well represented among Western Cape Iridaceae. These active, hairy beetles utilize various brightly coloured, open or bowl-shaped flowers as sites for reproduction and are often encountered on various species of Asteraceae and Iridaceae (Goldblatt *et al.* 1998). Flowers adapted to these beetles are typically ornamented with dark markings that act as beetle mimics, deceiving the insects through their resemblance to potential mates. Adaptations for this type of beetle pollination in *D. aurea* are the asymmetric enlargement of the lower or peripheral flowers in the inflorescence to imitate the ray florets of Asteraceae like *Arctotis* and *Gazania*, the lack of nectar, with associated vestigial staminal tube, and the absence of floral fragrance. Although the pollination biology of the remaining species, *D. capensis*, has not been studied, the peculiar structure of the flowers and their yeasty odour suggest that the species might be adapted to pollination by rodents. This strategy is also evident in one or two species of *Massonia* (Hyacinthaceae) (Johnson *et al.* 2001) as well as several species of *Androcymbium* Willd. (Colchicaceae) among the geophytes in Western and Northern Cape.

In all species of *Daubenya* the fruiting peduncle elongates at maturity, raising the infructescence above the ground, and then abscises to release it. Thereafter, the species differ markedly in seed dispersal strategies. In *D. comata* and *D. stylosa* no particular adaptations for seed dispersal appear to be developed and the relatively small capsules remain attached to the axis, shedding the seeds immediately around the plants. These autochorous species have short or vestigial pedicels that do not elongate at maturity and  $\pm$  ovoid capsules that are indehiscent, although the locules do eventually separate along the septa to release the seeds over time as they disintegrate. The remaining species exhibit a suite of adaptations to anemogeochoy or wind dispersal through tumbling (Van der Pijl 1982; Snijman & Linder 1996). The most prominent of these adaptations are the large, three-angled or -winged, loculicidally dehiscent capsule and the frequent detachment of the entire inflorescence as a single unit before seed release. In *D. marginata*, *D. namaquensis* and *D. zeyheri* the capsules abscise readily from the pedicels at maturity and are dispersed individually but in the remaining species they remain attached to the peduncle and the infructescence is dispersed as an entire unit. The surface area of the dispersal unit in these species is further increased by the prominent wings on the capsules in *D. alba* and *D. capensis*, giving them a kite-like appearance and by the large papery bracts in *D.*

*aurea*, which act as sails. The conversion of the infructescence into a tumbleweed is enhanced in *D. alba* and *D. capensis* through the elongation of the pedicels, increasing the size of the infructescence and giving it a rounded, balloon-like form. There is a remarkable similarity in the adaptations to wind dispersal of the fruits developed in these latter species and in the genus *Massonia*, particularly the obtriangular, winged capsules borne on relatively long pedicels to form a rounded, balloon-like structure that is readily dispersed by the wind. In *Massonia*, however, the pedicels are invariably subtended by large, sail-like bracts resembling those found in *D. aurea*. The smooth, globose seeds in the anemochorous species are easily shaken out of the capsules but do not appear to disperse significantly thereafter.

Anemogeochoy is well known in the family Amaryllidaceae: subtribe Amaryllideae (Snijman & Linder 1996) but has not been studied in the Hyacinthaceae. In both of these families, however, this mode of seed dispersal is more common in South Africa than elsewhere in the continent, and is best developed in the semi-arid, winter rainfall region.

## EVOLUTION

Sequence analysis of the *trnL-trnF* region of the chloroplast genome (Van der Merwe *et al.* in prep.) offers little resolution within the genus apart from indicating a close relationship between the species *D. alba* and *D. capensis*. This species pair is well defined morphologically by the cuneate, winged capsules borne on long pedicels. Their relationship to the remaining species as well as the relationships between these species remain unresolved. Although the similarity in floral form and capsules in *D. marginata* and *D. zeyheri* suggests that these two species are closely allied, further morphological assessment of relationships within the genus is confounded by the high degree of autapomorphies displayed by each species. Until further genetic analysis is complete, little more can be said about possible relationships between the species.

The genus *Daubenya* is essentially restricted to seasonally moist, usually clay depressions and all of the species respond to autumn rains, whether they occur in the winter or summer rainfall regions. There is thus little ecological diversification within the genus in response to climate or soils, which is probably not surprising given that all species are vegetatively indistinguishable. Apart from *D. comata* and *D. marginata*, species of *Daubenya* are local endemics that are rarely sympatric. Exceptions are the species pairs *D. aurea* and *D. marginata* in one or two localities, and *D. stylosa* and *D. capensis*. It is perhaps significant that the members of these pairs flower at different times, suggesting that flowering time operates as a prezygotic isolating mechanism between them. While there may be little diversification within the genus in response to climate or soil, *Daubenya* is unparalleled in the Hyacinthaceae in its floral radiation. This extreme variation can be linked to differences in pollination strategy and is accompanied by some variation in capsule morphology and seed dispersal mechanisms. Most species are anemochorous to some degree and adapta-

tions to wind dispersal of the seeds include both elaboration of the capsules themselves as well as enlargement of the inflorescence bracts. Exceptions are *D. stylosa* and possibly *D. comata*, which have indehiscent capsules with no apparent adaptations for seed dispersal. Although the anemochorous species are more diverse than those lacking obvious seed dispersal mechanisms, the individual species adapted to anemochory are not more widespread than the autochorous species. This suggests that anemochory in *Daubenya* has facilitated saltational speciation, whereby the occasional colonization of suitable new habitats through seed dispersal has favoured speciation through founder-effects and subsequent genetic drift.

#### TAXONOMIC HISTORY

The taxonomic history of the genus *Daubenya* reflects the significance that has traditionally been attached to floral differences among the Hyacinthaceae, resulting in the establishment of several monotypic genera between 1835 and 1936 for newly discovered species with distinctive flowers. The first of these genera, *Daubenya*, was established in 1835 by Lindley to accommodate the species *D. aurea*, which is characterized by extremely zygomorphic lower flowers. Floral zygomorphy is uncommon in the family Hyacinthaceae and this degree of zygomorphy does not occur elsewhere in the family. In his treatment of the sympetalous genera of the family Hyacinthaceae, Baker (1871) allied *Daubenya* with the genus *Massonia* in his tribe Massonieae on the basis of the reduced peduncle. Bentham (1883), however, included these two genera in his tribe Allieae because their congested inflorescences in which the flowers are subtended by large bracts suggested the umbel-like inflorescences of Alliaceae. Species related to *D. aurea* but with less well-developed bracts were placed by Baker (1871) first in section *Astemma* of *Massonia* and later in subgenus *Astemma* of *Polyxena* (Baker 1897). The species recognized by Baker (1871) in subgenus *Astemma* are those that are currently recognized as *D. comata*, *D. marginata* and *D. zeyheri* and he remarked at the time on the similarity between them and certain species of *Massonia*, with the suggestion that the two groups were best combined. This opinion was followed in recent treatments of the group (Jessop 1976; Müller-Doblies & Müller-Doblies 1997) but was not the view of Rudolf Schlechter (1924), who segregated the taxa placed by Baker in *Polyxena* subgenus *Astemma* as a distinct genus, *Neobakeria*, nor of Phillips (1951) or Dyer (1976). At the same time that Schlechter described *Neobakeria*, he also established another genus, *Androsiphon*, for a florally unusual species discovered a few years previously by his brother. Following this, yet another monotypic genus was established by Barker (1936), for the species *Amphisiphon stylosa*. These two genera were combined by Phillips (1951) but have been retained as distinct by subsequent workers, starting with Dyer (1976) and Jessop (1976). Recent studies on the molecular systematics of the group reject the recognition of these genera. The characters on which these various genera were based are best seen as extreme adaptations to a variety of pollination and seed dispersal strategies (Goldblatt & Manning 2000). Those species with more conventional

flowers that were previously placed in *Neobakeria* are now also confirmed to be closely allied to these florally more unusual species. Although all of these genera were included in an expanded concept of the genus *Daubenya* (Goldblatt & Manning 2000), not all of the species were transferred to that genus and this is accordingly done here.

#### SYSTEMATIC TREATMENT

***Daubenya* Lindl.** in Botanical Register 21: t. 1813 (1835); Baker: 394 (1871); Baker: 417 (1897); E. Phillips: 193 (1951); R.A. Dyer: 940 (1976); Jessop: 431 (1976); U.Müll.-Doblies & D.Müll.-Doblies: 91 (1997). Type: *D. aurea* Lindl.

*Polyxena* Kunth subgenus *Astemma sensu* Baker: 419 (1897) non *Massonia* Thunb. section *Astemma* Endl.: 145 (1836).

*Androsiphon* Schltr.: 148 (1924); Jessop: 432 (1976); U.Müll.-Doblies & D.Müll.-Doblies: 86 (1997). Type: *A. capense* Schltr.

*Neobakeria* Schltr.: 150 (1924); U.Müll.-Doblies & D.Müll.-Doblies: 86 (1997). Type: *N. namaquensis* Schltr.

*Amphisiphon* W.F. Barker: 19 (1936); Jessop: 432 (1976); U.Müll.-Doblies & D.Müll.-Doblies: 86 (1997). Type: *A. stylosa* W.F. Barker.

Deciduous geophytes. *Bulb* turbinate to globose, sometimes deeply buried; outermost tunics leathery, dark brown, extending in a neck as narrow, flat, papery segments. *Leaves* 2, spreading to prostrate, lanceolate to ovate, longitudinally striate, glossy green, bases clasping peduncle for some distance. *Inflorescence* corymbose or racemose to subspicate, congested and capitate to conical; peduncle subterranean in flower but elongating from base in fruit and then well-exserted; bracts usually small, rarely large, usually increasing in size acropetally, the uppermost sterile, often forming a coma; pedicels suberect, vestigial to well developed in lower flowers but decreasing in length acropetally, sometimes elongating slightly in fruit. *Flowers* white to lilac, greenish yellow or red, strongly scented or unscented, actinomorphic or sometimes dimorphic with lower flowers slightly or strongly bilabiate, sympetalous; perianth tube cylindrical or somewhat dorsoventrally compressed, shorter in upper flowers, sometimes either adaxial or abaxial part of tube longer than opposing part in lower flowers; tepals spreading to suberect or recurved, rarely erect and connate, linear to oblanceolate, usually subsimilar but sometimes lower three much enlarged. *Stamens* erect or slightly spreading; filaments subequal or adaxial ones slightly longer, free or fused below into short or long tube, inserted on base of tepals but sometimes tepals fused above filament insertion and then filaments apparently arising within perianth tube; anthers dorsifixed. *Ovary* ovoid; style usually between two-thirds and as long as filaments; stigma penicillate; ovules 6–8 in two series per locule. *Infructescence* toppling over at maturity through elongation of lower part of peduncle. *Capsule* papery, obovoid, and 3-angled or sometimes somewhat inflated and 3-winged, acute or retuse at apex, usually dehiscing loculicidally from top, rarely indehiscent, style rarely persistent as a beak. *Seeds* globose, smooth and glossy, black.



Species eight, South Africa, mainly the more arid winter rainfall parts.

Key to species

- 1a Lower flowers strongly zygomorphic with lower three tepals much enlarged, oblanceolate and several times longer than upper tepals; perianth red or yellow; lower bracts large, 25–35 mm long ..... 8. *D. aurea*
- 1b Lower flowers not or weakly zygomorphic with tepals sub-similar; perianth yellow to white or pinkish; lower bracts small or large, 1–30 mm long:
  - 2a Filaments united into narrow tube 8–12 mm long:
    - 3a Pedicels 1–3 mm long; tepals ± connate into a narrow tube above stamen insertion ..... 7. *D. stylosa*
    - 3b Pedicels 12–25 mm long; tepals spreading and free above stamen insertion:
      - 4a Flowers white; perianth tube 12–27 × 1.2–2.0 mm; tepals linear-oblanceolate ..... 5. *D. alba*
      - 4b Flowers yellow; perianth tube 6–10 × 3–4 mm; tepals oblong to ovate ..... 6. *D. capensis*
  - 2b Filaments free or shortly united into wide-mouthed tube up to 3 mm long:
    - 5a Perianth tube of lower flowers 25–45 mm long; tepals recurved; filaments free, white or flushed lilac ..... 1. *D. comata*
    - 5b Perianth tube of lower flowers 10–25 mm long; tepals spreading or suberect; filaments free or shortly united into tube, yellow to red:
      - 6a Lowermost flowers zygomorphic through basal fusion of upper tepals; tepals linear; flowers fragrant ..... 2. *D. namaquensis*
      - 6b Lowermost flowers actinomorphic; tepals ovate to lanceolate; flowers unscented:
        - 7a Inflorescence conical, topped with conspicuous coma of coloured bracts; perianth tube compressed-cylindrical, 2–3 mm diam.; stamens uniformly yellow to red ..... 3. *D. marginata*
        - 7b Inflorescence capitate, sometimes with inconspicuous coma of green bracts; perianth tube cylindrical, 1–2 mm diam.; stamens orange to red with basal collar flushed deep purple ..... 4. *D. zeyheri*

1. *Daubenya comata* (Burch. ex Baker) J.C.Manning & A.M.van der Merwe, comb. nov.

*Massonia comata* Burch. ex Baker in Journal of the Linnean Society, Botany 11: 392 (1871); Jessop: 421 (1976); U.Müll.-Doblies & D.Müll.-Doblies: 68 (1997). *Polyxena comata* (Burch. ex Baker) Baker: 419 (1897). *Neobakeria comata* (Burch. ex Baker) Schltr.: 150 (1924). Type: Northern Cape, Noupoot Dist., Carolus Poort, 19 March 1813, Burchell 2751 (K, holo.).

Bulb subglobose, 20–35 mm diam., deeply buried; outer tunics leathery, dark brown, extending in a papery neck up to 30 mm long. *Leaves* 2, spreading to prostrate, ovate to lanceolate, 60–150 × 30–90 mm, bases clasping peduncle for up to 80 mm, dark green or flushed maroon. *Inflorescence* subspicate, capitate, exerted up to 20 mm above leaves; bracts increasing in size acropetally, lowermost linear or awl-shaped, white, 7–12 mm long, those above gradually becoming broader, ovate to lanceolate, up to 10 × 2 mm, uppermost sterile, forming a coma, green or flushed pinkish, up to 8 × 3 mm; pedicels vestigial, lowermost up to 1 mm long, flowers subsessile. *Flowers* white or flushed pink, strongly scented during the day and night, fragrance sweet and spicy; weakly dimorphic, lower flowers slightly bilabiate, upper flowers actinomorphic; perianth tube cylindrical or abaxial surface flattened, lightly curved outwards, (25–)30–35(–45) mm long in lower flowers, ± 15 mm long in upper flowers, 2–3 mm diam.; in lower flowers adaxial half of tube ± 1 mm longer than abaxial half, with short sinus between upper three and lower three tepals; tepals spreading from base and then recurved or coiling downwards, linear-oblong to narrowly oblanceolate, up to 7 × 1.5–2.0 mm. *Stamens* erect at anthesis, later spreading slightly above; filaments subequal or adaxial ones slightly longer, free, inserted on or up to 1 mm above base of tepals, (7–)10–15 mm long; anthers pink, 2.5–3.0 mm long before dehiscence. *Ovary* ovoid, ± 3 mm long; style reaching to just below or slightly above filaments, 20–40 mm long. *Capsule* obovoid, 3-angled but rounded on angles, 10–12 × 7–8 mm. *Seeds* globose, ± 2 mm diam. *Flowering time*: mid April to mid May. Figure 1; Plate 1A.

*Distribution and ecology*: *Daubenya comata* is scattered across the western portion of the South African

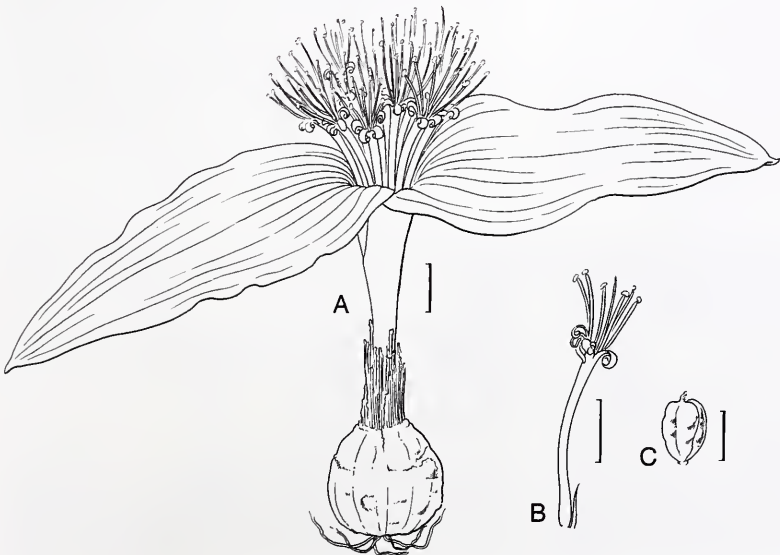


FIGURE 1.—*Daubenya comata*. A, whole plant; B, lower flower and bract; C, capsule. Scale bars: A–C, 10 mm. Artist: John Manning.

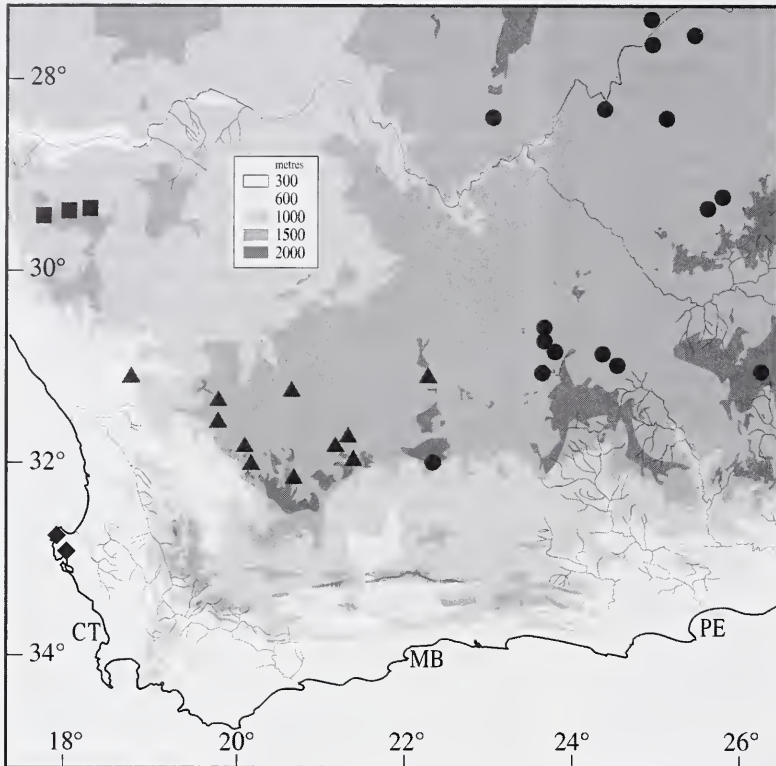


FIGURE 2.—Distribution of *Daubenya comata*, ●; *D. namaquensis*, ■; *D. marginata*, ▲; *D. zeyheri*, ◆.

central plateau where it is largely restricted to altitudes between 1 200–1 500 m, bordering the western rim of the drainage basin of the Orange/Gariep and Vaal Rivers (Figure 2). It has been recorded from Beaufort West near the northern border of the Western Cape, eastwards to Molteno in the Eastern Cape, through the Free State and eastern parts of the North-West as far north as Barberspan near Delareyville. Plants grow in colonies in seasonally waterlogged loam or clay, particularly the red, glutinous clays derived from the doleritic sills that are frequently exposed across the interior plateau. These soils retain moisture and remain damp for longer than the surrounding karoo shales. Like *D. namaquensis*, another early flowering species, *D. comata* responds to late summer showers, flowering before the soils dry up and the temperatures drop too low for active growth. It shares this strategy and habitat with several other sympatric dwarf geophytes with a similar growth habit, particularly *Androcymbium asteroides*, *Moraea falcifolia* and *Polyxena ensifolia*.

The white or pink flowers are strongly and sweetly scented throughout the day and night. They secrete small amounts of nectar and are pollinated by pollen- and nectar-collecting bees during the day (*Apis mellifera* and *Anthophora* sp.) and by small noctuid moths during the night.

**Diagnosis and relationships:** *D. comata* is readily recognized by the capitate inflorescence of strongly scented, white flowers with narrow, recurved or coiled tepals and free filaments. The lowermost flowers are very slightly bilabiate through a slight asymmetry in the length of the perianth tube, in the same way but to much less a degree than in *D. namaquensis*. The two species also resemble

one another in their free filaments but they differ in inflorescence shape, flower colour and in the form and size of the capsules. The small, sessile capsules in *D. comata* are rounded on the sides and quite unlike the inflated and angled or winged capsules that characterize the other species in the genus.

**History:** *D. comata* was first collected on the Farm Caroluspoort, just south of the Free State border near Noupoot, on 19 March 1813 (McKay 1943) by the naturalist and traveller William John Burchell. Fifty years were to elapse before the species was formally published by the Kew botanist J.G. Baker in 1871, with due acknowledgement to Burchell, who had sketched and named the species in his field notebook at the time of its original collection. It is now known to be widespread, although scattered, across the southern African central plateau.

**Conservation status:** Not endangered.

**2. *Daubenya namaquensis* (Schltr.) J.C.Manning & Goldblatt** [*'D. namaquana'*], in Goldblatt & Manning in *Strelitzia* 9: 713 (2000).

*Neobakeria namaquensis* Schltr.: 150 (1924); U.Müll.-Doblies & D.Müll.-Doblies: 86 (1997). Type: South Africa, Northern Cape, Springbok Dist., Zabies (= Sabies), 4 June 1896, *M. Schlechter* 90 (B, holo.; BOL!, GRA, PRE, SAM!, Z).

*Massonia angustifolia* sensu Jessop: 419 (1976) in part.

**Bulb** turbinat, 20–35 mm diam., deeply buried; outer tunics leathery, dark brown, extending in a papery neck up to 30 mm long. **Leaves** 2, spreading to prostrate, lanceolate, 100–150 × 25–70 mm, bases clasping pedun-

cle for up to 100 mm, dark green. *Inflorescence* subspicate, conical, exerted up to 90 mm above leaves; bracts increasing in size acropetally, lowermost awl-shaped, white, 1–2 mm long, those above gradually becoming longer and oblanceolate, up to 6 × 3 mm, uppermost sterile, forming a coma, spatulate, green or flushed pinkish, up to 8 × 3 mm; pedicels suberect, decreasing in length acropetally, lowermost up to 5 mm long, uppermost up to 0.5 mm long, flowers subsessile. *Flowers* greenish yellow, strongly scented during the day and night, fragrance sweet and spicy, carnation-like; dimorphic, lower flowers slightly bilabiate, upper flowers actinomorphic; perianth tube cylindrical or abaxial surface flattened, lightly curved outwards, 13–15 mm long in lower flowers, 9–10 mm long in upper flowers, ± 2 mm diam.; in lower flowers adaxial half of tube ± 2 mm longer than abaxial half with pronounced sinus between upper three and lower three tepals; tepals spreading from base and curving upwards in outer half, linear-oblanceolate, 9–10 × 1–1.5 mm, apices weakly cucullate. *Stamens* erect at anthesis, later spreading slightly above; filaments subequal or adaxial ones slightly longer, 13–15 mm long, free, inserted on base of tepals; anthers yellow, up to 2.5 mm long before dehiscence. *Ovary* ovoid, ± 3 mm long; style reaching to between two-thirds and as long as filaments, 15–25 mm long. *Capsule* abscising at maturity, obovoid, 20–23 × 15 mm, somewhat inflated, 3-angled and introrse at base but 3-winged and obtuse at apex, dehiscing loculicidally from top. *Seeds* globose, ± 2 mm diam. *Flowering time*: mid May to mid June. Figure 3; Plate 1B.

*Distribution and ecology*: *Daubenya namaquensis* is known from a few collections made in the semi-arid flats east of Okiep and Springbok at an altitude of 1 000 m (Figure 2). This region, just east of Namaqualand proper and on the extreme western edge of Bushmanland, lies on the boundary between winter and summer rainfall regions

and in consequence receives both erratic late summer showers as well as some rain from the occasional winter frontal system that extends inland from Namaqualand. The species responds rapidly to autumn rains and flowers in early winter before temperatures drop too low for active growth. Plants of *D. namaquensis* occur in small colonies in deep red sands in a vegetation dominated by the willowy shrub, *Sisymbrium sparteum* (Zygophyllaceae) and the tussock grass, *Stipagrostis namaquensis*. The colonies are restricted to lower-lying drainage areas in which the water table remains nearer the surface. The very deeply seated bulbs are an obvious adaptation enabling the plants to make use of this soil moisture.

The greenish yellow flowers are strongly and sweetly clove-scented throughout the day and night. They secrete small amounts of nectar and are probably pollinated by a variety of diurnal and nocturnal insects, including bees and moths.

*Diagnosis and relationships*: *D. namaquensis* is distinguished by the well-exserted conical inflorescence of strongly scented, yellow flowers with linear tepals and free filaments. Although confused by Jessop (1976) with *D. marginata*, the resemblance between the two species is very superficial, encompassing nothing more than the prominent inflorescence topped by a coma of sterile bracts. The flowers of *D. marginata* are unscented, with ovate, whitish or pale yellow tepals and golden yellow or orange filaments that are fused at the base into a short collar. A distinct feature of *D. namaquensis* is the bilabiate lower flowers in which the upper side of the perianth tube is prolonged for ± 2 mm beyond the lower side, resulting in a distinct sinus between the three upper and three lower tepals. This differential in the tube length rapidly becomes less evident higher up the inflorescence and the upper flowers are quite actinomorphic. This asymmetry



FIGURE 3.—*Daubenya namaquensis*. A, whole plant; B, lower flower and bract. C, D, upper flower; E, capsule. Scale bars: A–E, 10 mm. Artist: John Manning.



in the lower flowers is not very evident without careful examination, especially in pressed material. It occurs also, although to a lesser degree, in some other species of *Daubenya*, particularly *D. comata* and *D. stylosa*.

**History:** *D. namaquensis* was first collected by Max Schlechter during a trip to Namaqualand with his brother, the botanist Friedrich Richard Rudolf Schlechter, soon after his arrival in South Africa in May 1896. Two decades were to pass before it was described, when it formed the basis of the genus *Neobakeria*, established by Rudolf Schlechter to accommodate the group of species until then treated as *Polyxena* subgenus *Astemma*. These seven species were distinguished from *Polyxena* s. str. by their uniseriate stamens, and from *Massonia* by their inconspicuous bracts. Although struck by the well-exserted, foxtail-like inflorescence of *D. namaquensis*, Schlechter ironically overlooked the even more diagnostic zygomorphy of the lower flowers through dissecting only the more accessible upper flowers, which are perfectly actinomorphic. This characteristic was also overlooked by Jessop (1976), who confused the species with *D. marginata*. The curious zygomorphy of the lower flowers of *D. namaquensis* was only recently highlighted by Müller-Doblies & Müller-Doblies (1997). They used it as the basis for restricting the circumscription of the genus *Neobakeria* to this species alone, while in turn overlooking the fact that floral zygomorphy of the same type occurs, albeit to a lesser extent, in both *D. comata* and *D. stylosa*. Over a century was to pass before the species was collected for the second time and it is still known from only a handful of specimens.

**Conservation status:** Endangered (B1+2c, D).

### 3. *Daubenya marginata* (Willd. ex Kunth) J.C. Manning & A.M. van der Merwe in Bothalia 32: 65 (2002).

*Massonia marginata* Willd. ex Kunth: 299 (1843). *Polyxena marginata* (Willd. ex Kunth) Benth. & Hook. ex T. Durand & Schinz: 366 (1895). *Neobakeria marginata* (Willd. ex Kunth) Schltr.: 150 (1924). Type: South Africa, Caput Bonae Spei (B-WILLD 6373, holo., -NBG, photo.).

*Massonia rugulosa* Licht. ex Kunth: 299 (1843). *Polyxena rugulosa* (Licht. ex Kunth) Baker: 420 (1897). *Neobakeria rugulosa* (Licht. ex Kunth) Schltr.: 150 (1924). Type: Caput Bonae Spei, Lichtenstein 224 (B, holo., ?destroyed).

*Polyxena haemanthoides* Baker: t. 1727 (1888); E. Phillips: t. 56 (1922a). *Neobakeria haemanthoides* (Baker) Schltr.: 150 (1924). Type: South Africa, Nuweveld Mountains near Fraserburg, April 1886, *Bolus* 5493 [BOL, lecto.], designated by J.C. Manning & A.M. van der Merwe: 65 (2002); G, SAM!].

*Massonia angustifolia* auct. non *M. angustifolia* L.f. (= *M. echinata* L.).

Bulb subglobose, 20–30 mm diam., shallowly buried; outer tunics leathery, dark brown, extending as a papery neck up to 40 mm long. *Leaves* 2, spreading, ovate to elliptic, 50–100 × 25–50 mm, base clasping peduncle for 20–30 mm, apiculate, dark green or flushed maroon. *Inflorescence* subsapiculate, capitate or conical, exserted 20–60 mm above leaves at flowering; bracts erect, lowermost triangular, 2–5 mm long, becoming oblanceolate-spathulate acropetally, up to 8 × 3 mm, uppermost ster-

ile, imbricate, forming a short or elongate coma flushed orange, up to 10 × 5 mm; pedicels 1.0–2.5 mm long. *Flowers* greenish yellow with yellow or orange stamens, unscented; perianth tube compressed-cylindrical, 10–15(–20) × 2–3 mm; tepals suberect, inner three connate for 0.5–1.0 mm beyond outer three, lanceolate, conduplicate, 6–8 × 2.5 mm. *Stamens* connate for 1.5–2.5 mm in a wide-mouthed, slightly flaring staminal collar; filaments suberect and lightly incurved, 10–15(–22) mm long; anthers yellow, 2.0–2.5 mm long before anthesis. *Ovary* ovoid, ± 6 mm long; style lightly deflexed, 11–20 mm long. *Capsule* abscising at maturity, ellipsoid to obovoid, 12–15 × 15–20 mm, somewhat inflated, introrse at base, obtuse at apex, 3-angled below but 3-winged at apex. *Seeds* globose, ± 2.5 mm diam., glossy black. *Flowering time:* May to July, rarely to August. Figure 4; Plate 1C.

**Distribution and ecology:** *Daubenya marginata* is widespread across the Roggeveld Escarpment and western karoo at altitudes of 1 000–1 500 m, from near Calvinia and Williston southwards to Sutherland, thence eastwards along the Nuweveld scarp as far inland as Fraserburg and Loxton (Figure 2). A few isolated populations occur to the west, below the Bokkeveld Escarpment, at an altitude of 200 m in the Knersvlakte north of Vanrhynsdorp. Populations occur on silt or gritty clay, more rarely red clays derived from dolerite, in seasonally moist depressions or washlines. *D. marginata* grows sympatrically with *D. aurea* in some colonies but flowers several months earlier.

**Diagnosis and relationships:** *D. marginata* is morphologically very close to *D. zeyheri* and the two were regarded as conspecific by Jessop (1976). There are, however, several differences between them, some rather subtle. In *D. marginata* the inflorescence is typically conical and protrudes above the leaves, and is invariably surmounted by a coma of conspicuous yellow or orange, often spatulate bracts. The globular inflorescence of *D. zeyheri*, in contrast, does not protrude much above the leaves and is at most topped by an inconspicuous coma of narrow, green bracts. The two species differ also in flower form and colour, although in both the perianth tube varies greatly in length. In *D. marginata* the perianth tube is always conspicuously flattened and 2–3 mm in diameter, the tepals tend to be flushed yellow and firm-textured and the filaments are uniformly pigmented yellow to orange or red. The flowers of *D. zeyheri*, in contrast, are characterized by a much more slender perianth tube 1.0–1.5 mm in diameter, white tepals that tend to be almost papery in texture and, most conspicuously, reddish filaments that are flushed deep purple at the base where they are fused into a shallow collar.

The plants with their orange to reddish stamens and conical inflorescence topped with enlarged orange or yellow bracts are conspicuous when in flower and are visited by Malachite sunbirds which probe the flowers for nectar. The relatively broad tubes contain abundant nectar that accumulates in the wide-mouthed staminal collar where it is readily accessible to the birds, which feed from the ground. The lack of floral scent is also consistent with bird pollination.



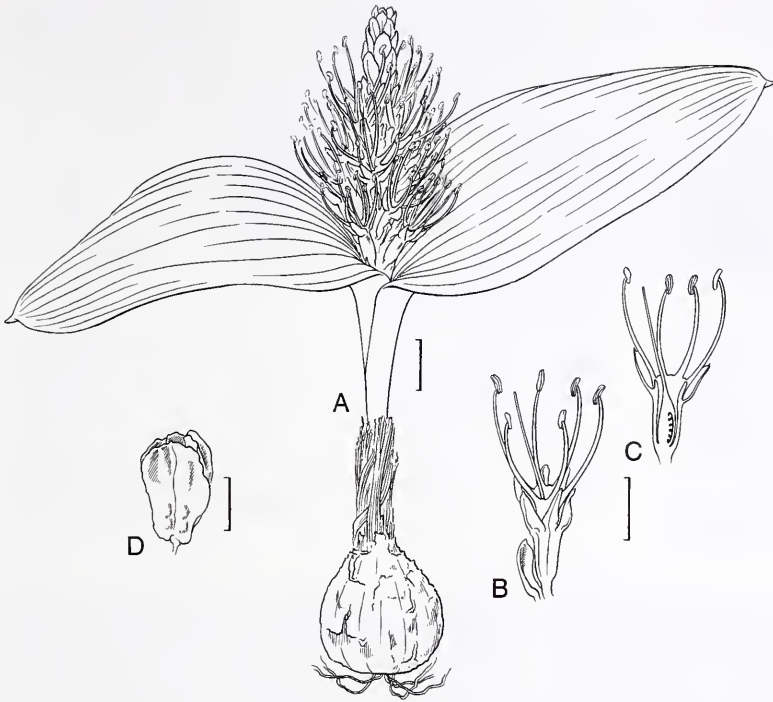


FIGURE 4.—*Daubenya marginata*.  
A, whole plant. B, C, flower:  
B, with bract; C, lvs. D, cap-  
sule. Scale bars: A–D, 10  
mm. Artist: John Manning.

**History:** the true identity of this species has been misunderstood ever since the Kew botanist J.G. Baker confused it with *Massonia angustifolia* L.f., possibly as early as 1871 but certainly by 1897. This mistake was perpetuated by subsequent authors until recently, when it was shown that *M. angustifolia* is actually conspecific with *Massonia echinata* L. (Manning & Van der Merwe 2002). The species known by all authors after Baker as *M. angustifolia* is in fact properly known as *Daubenya marginata*, first described as *Massonia marginata* by the Berlin Botanist Carl Kunth. Although known to his predecessor, Carl Willdenow, it was not formally named until Kunth (1843) published the name that had earlier been suggested for it by Willdenow. The collector and place of collection of the type specimen are unknown. The species was later described as *Polyxena haemanthoides* by Baker in 1888, based on a plant collected by the Cape Town stockbroker and botanist, Harry Bolus, on the Nuweveld Mountains near Fraserburg in April 1886. It seems that Bolus intended describing the species himself, as *Haemantholirion capense*, but Baker must have dissuaded him from this step. Baker did, however, retain the reference to the genus *Haemanthus* (Amaryllidaceae) that the appearance of the plant had suggested to Bolus. Baker, although suspecting that his species was similar to Kunth's, had not seen material of *M. marginata* and thus described it as new. The species was recognized until Jessop (1976) revised the genus. Unconvinced that the apparent differences between it and *D. zeyheri* were significant, he combined the two taxa under the misapplied name *M. angustifolia*.

**Conservation status:** Not endangered.

4. *Daubenya zeyheri* (Kunth) J.C.Manning & A.M.van der Merwe, comb. nov.

*Massonia zeyheri* Kunth in Enumeratio plantarum 4: 298 (1843); U.Müll.-Doblies & D.Müll.-Doblies: 77 (1997). *Polyxena zeyheri* (Kunth) Benth. & Hook. ex T.Durand & Schinz: 367 (1895). Type: without locality or date, *Zeyher* 298 [†B, holo. destroyed; K, lecto!., designated by Jessop: 419 (1976)].

*Massonia pedunculata* Baker: 8 (1892). Type: South Africa, Malmesbury Dist., near Hopefield, Schaapplaatsfontein, June 1887, *Bachmann* 2043 (K, lecto!., here designated; B.–BOL, drawing!).

*Massonia burchellii* Baker: 393 (1871). *Polyxena burchellii* (Baker) Baker: 420 (1897). *Neobakeria burchellii* (Baker) Schltr.: 150 (1924). Type: South Africa, Caput Bonae Spei, *Burchell* s.n. (K, holo!.,–BOL, drawing!).

*Massonia angustifolia* auct. non *M. angustifolia* L.f. (= *M. echinata* L.).

Bulb subglobose, 20–30 mm diam., outer tunics leathery, dark brown, extending as a papery neck up to 10 mm long. *Leaves* 2, spreading, elliptic to lanceolate, 60–150 × (10–)30–80 mm, bases clasping peduncle for 10–100 mm, apiculate, dark green. *Inflorescence* corymbose, capitate, exserted 20–40 mm above leaves; bracts erect, lowermost triangular, 2–3 mm long, becoming lanceolate acropetally and increasing in size, up to 8 × 2 mm, uppermost sometimes sterile and forming inconspicuous coma; pedicels 2–10 mm long, lowermost sometimes longer than upper. *Flowers* translucent, whitish tinged pink on tube, stamens reddish tinged purple at the base, papery in texture, unscented; perianth tube cylindrical, lightly constricted at mouth, 12–20 mm long in lower flowers but rarely more than 13 mm in upper flowers, 1.5–2.0 mm diam, inner tepals connate for 0.5–1.0 mm beyond outer ones; tepals spreading at base then suberect, lanceolate, conduplicate, 6–10 × 2.5–3.0 mm. *Stamens* reddish but staminal collar purple, connate for 1.0–1.5 mm in a flaring staminal collar; filaments suberect, 12–19 mm long; anthers yellow or reddish, 2–3 mm long before anthesis. *Ovary* ovoid, ± 4 mm long;

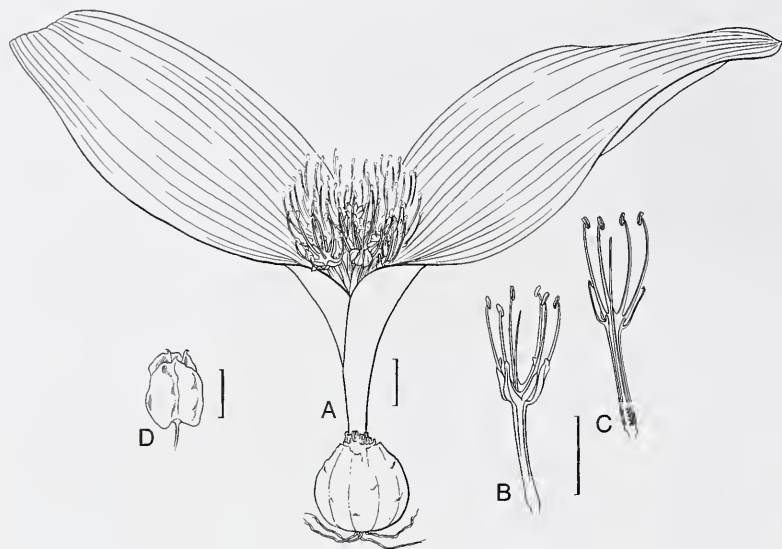


FIGURE 5.—*Daubenya zeyheri*. A, whole plant. B, C, flower: C, l/s. D, capsule. Scale bars: A–D, 10 mm. Artist: John Manning.

style 15–30 mm long. *Capsule* abscising at maturity, broadly ovoid, 10–15 × 9–13 mm, somewhat inflated, 3-angled, introrse at base, obtuse at apex. *Seeds* globose, ± 2.5 mm diam., glossy black. *Flowering time*: late May and June to early July. Figure 5; Plate 1D:

**Distribution and ecology:** *Daubenya zeyheri* is a coastal species occurring near sea level, unlike the other species in the genus, which occur at higher altitudes inland. It is restricted to the west coast of Western Cape, where it is now known from only three locations, one at Paternoster and Cape Columbine and the others less than 20 km to the south, near Saldanha (Figure 2). The material that formed the type of *M. pedunculata* was collected 10 km southeast of Hopefield on the Farm Schaapplaatsfontein but no further collections have been made from here and this population has presumably disappeared under wheat. *D. zeyheri* grows on sandy calcareous soils overlying limestone, sometimes in dense colonies.

The flowers, with their reddish filaments and contrasting glistening purple centres attract the attention of Lesser double-collared sunbirds, which probe the flowers for the copious nectar that is held in the wells formed by the staminal collars. The lack of floral fragrance is typical of bird-pollinated flowers.

**Diagnosis and relationships:** although closely related to *D. marginata* and sometimes difficult to separate from it in the dry state, living plants of *D. zeyheri* are readily recognized by the conspicuous purple centres to the flowers. The pigmentation is restricted to the staminal collar and when this is filled with nectar the flowers appear to have a glistening black centre that is quite lacking in *D. marginata*, in which the stamens are uniformly yellow or orange to reddish. Other more subtle differences between the two species are discussed under *D. marginata*. The two were treated as conspecific by Jessop (1976).

**History:** *D. zeyheri* has been described several times under different names but the earliest name dates from

1843, when the species was described by the Berlin botanist, Carl Kunth, from a collection made by the professional plant collector, Carl Zeyher. Zeyher's collection was made sometime between 1829 and 1834, probably near Saldanha Bay, which is still one of only two sites where the species is known to occur. The species was redescribed twice, both times by the Kew botanist J.G. Baker. In 1892 he described *Massonia pedunculata* from a specimen collected near Hopefield by the German naturalist Frans Bachmann, who practised medicine in the village from 1886–1887. A few years later he named *Massonia burchellii* from a collection made by the naturalist and traveller William John Burchell. Baker was clearly unsure about the exact identity of several of his species because he later transferred *M. burchellii* to *Polyxena* while leaving *M. pedunculata* in *Massonia*, although noting that it lacked the large bracts that are so characteristic of the genus.

**Conservation status:** Endangered (B1+2c, C2).

5. *Daubenya alba* A.M.van der Merwe, in A.M.van der Merwe & Marais in South African Journal of Botany 68: 312 (2002). Type: South Africa, Northern Cape, 25 km SW Middelpos, Farm Botuin, June 2001, Van der Merwe 195 (NBG, holo.!).

Bulb subglobose to turbinate, 10–15 mm diam., usually shallowly buried; outer tunics leathery, brown, extending in a short, papery neck up to 5 mm long. *Leaves* 2, suberect to spreading, ovate to lanceolate, 40–100 × 15–50 mm, bases flushed red and clasping peduncle for up to 30 mm, dark green. *Inflorescence* corymbose, capitate, exerted up to 20 mm above leaves; bracts ovate-lanceolate, 3–4 mm long; pedicels well developed, lowermost 12–19 mm long, elongating slightly in fruit and ultimately 20–25 mm long. *Flowers* mauve or white with tips of tepals, filaments and exposed portion of style flushed pale lilac or mauve, strongly scented during the day and night, fragrance sweet and spicy, actinomorphic; perianth tube cylindri-

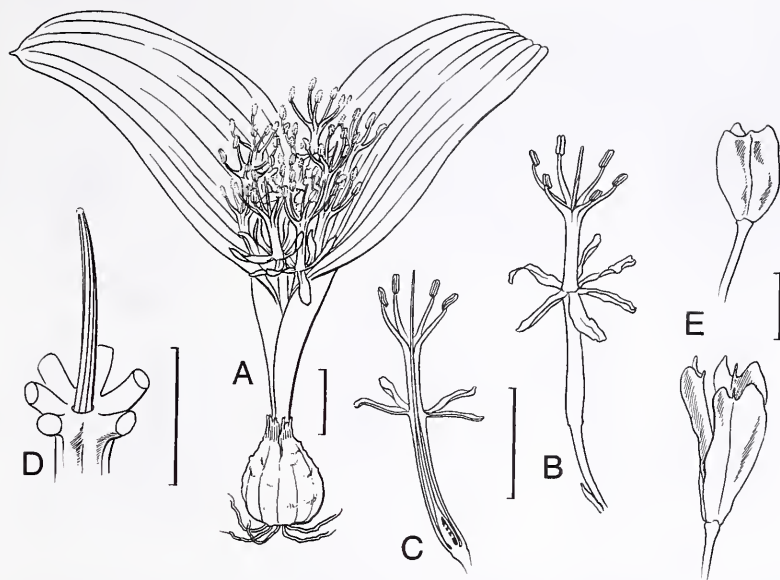


FIGURE 6.—*Daubenya alba*. A, whole plant. B–D, flower: B, with bract; C, l/s; D, detail of mouth of staminal tube. E, capsules. Scale bars: A–C, E, 10 mm; D, 5 mm. Artist: John Manning.

cal, (10–)12–25(–27) mm long, 1.5–2.0 mm diam.; tepals spreading from base, linear-oblong to narrowly oblanceolate, (8–)10–13 × 1.5–2.0 mm. *Stamens* connate below into cylindrical tube 8–10(–20) mm long, free parts suberect or lightly incurved at tips, (6–)8–15 mm long; anthers brown to purple, ± 2 mm long before dehiscence. *Ovary* ovoid, ± 4 mm long; style reaching up to 2 mm beyond anthers, 28–30(–50) mm long. *Capsule* ovoid-cuneate to obtriangular, (12–)20–25 × 10–12 mm, tapering below, deeply retuse above, three-winged. *Seeds* globose, 2.0–2.5 mm diam., glossy black. *Flowering time*: mid May to mid June. Figure 6; Plate 1E.

*Distribution and ecology*: *Daubenya alba* is known from a few scattered localities along the edge of the Roggeveld Escarpment between Calvinia and Middelpos at an altitude of 1 000–1 500 m (Figure 7). The plants

grow in colonies in seasonally waterlogged doleritic clay, on low hills or at the foot of rocky dolerite outcrops.

*Diagnosis and relationships*: *D. alba* is readily recognized by its white to lilac flowers with the stamens fused below into a narrow tube 6–10 mm long. The slight zygomorphy of the lowermost flowers, resulting from a slight asymmetry in the staminal tube, that is mentioned in the original description, is not always evident. The relationships of *D. alba* appear to lie with *D. capensis*, which it resembles in several respects, particularly its relatively long pedicels, cylindrical staminal tube and large, obtriangular capsules that are deeply retuse at the apex. The two species are readily distinguished by their flowers. In *D. capensis* the firm-textured flowers are bright yellow with a shorter, broader tube, 6–10 mm long and ovate tepals. The flowers of *D. alba* are altogether more delicate, with a slender perianth tube, 12–20 mm long and narrowly oblanceolate tepals. In addition *D. alba* lacks the conspicuous disc occluding the mouth of the staminal tube that is characteristic of *D. capensis*.

*History*: the most recently discovered species in the genus, *D. alba* was in cultivation in a few specialist collections by the early 1990s, although the type material was only collected from the wild in June 2001.

*Conservation status*: Vulnerable (B1+2c, D).

6. *Daubenya capensis* (Schltr.) A.M.van der Merwe & J.C.Manning, in Goldblatt & J.C.Manning in *Strelitzia* 9: 713 (2000).

*Androsiphon capense* Schltr.: 148 (1924); Brandham: 124 (1990); U.Müll.-Doblies & D.Müll.-Doblies: 86 (1997). Type: South Africa, Northern Cape, Calvinia Dist., Onder-Bokkeveld, Oorlogskloof, 2500 ft, July 1897, R. Schlechter 10969 (B, holo.; BOL!, G, GRA, PRE, Z).

*Bulb* subglobose, 20–30 mm diam., outer tunics leathery, dark brown, extending as a very short, papery neck up to 5 mm long. *Leaves* 2, spreading, ovate to elliptic,

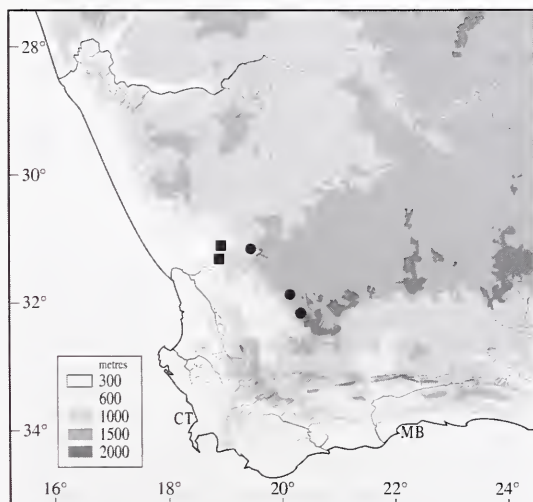


FIGURE 7.—Distribution of *Daubenya alba*, ●, *D. capensis*, ■.



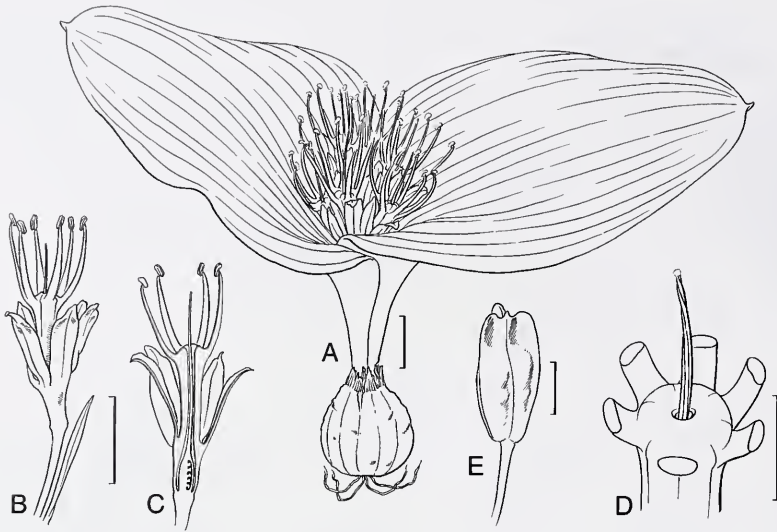


FIGURE 8.—*Daubenya capensis*. A, whole plant. B–D, flower: B, with bract; C, l/s; D, detail of mouth of staminal tube. E, capsule. Scale bars: A–C, E, 10 mm; D, 5 mm. Artist: John Manning.

50–150 × 25–90 mm, bases clasping peduncle for 20–80 mm, apiculate, dark green. *Inflorescence* corymbose, capitate, 30 × 40 mm; bracts erect, linear-ob lanceolate, lowermost 25–30 × 2–3 mm, becoming shorter acropetally, uppermost oblanceolate-spathulate; pedicels 15–25 mm long, elongating slightly in fruit and ultimately 20–30 mm long. *Flowers* firm-textured, golden yellow with staminal column and operculum flushed reddish orange and style streaked with red, yeast-scented; perianth tube subcylindrical, widening slightly upwards, 6–10 × 3–4 mm; tepals suberect, inner three sometimes connate for up to 1 mm beyond outer three, oblong to oblanceolate, 11–15 × 3–4 mm. *Stamens* connate in a stiff, thick-walled cylinder for 9–12 mm, top of tube occluded by convex disc or operculum through which style protrudes, upper portion of filaments suberect and lightly incurved, 10–14 mm long; anthers yellow, 2.0–2.5 mm long before anthesis. *Ovary* ovoid, ± 6 mm long; style erect, 20–25 mm long. *Capsule* ovoid-cuneate to obtriangular, 20–30 × 10–12 mm, tapering below, three-winged with apex deeply retuse. *Seeds* globose, ± 2.5 mm diam., glossy black. *Flowering time*: late June and July, rarely early August. Figure 8; Plate 1F.

*Distribution and ecology*: *Daubenya capensis* is endemic to the immediate vicinity of Nieuwoudtville, where it is known from several populations around the village at an altitude of 800 m (Figure 7). It is restricted to seasonally moist dolerite flats in red clay. The large, prominently three-winged capsules borne on relatively long pedicels form a rounded, balloon-like infructescence that is readily dispersed by the wind.

The curious disc that occludes the mouth of the tube is glossy and has the appearance of being wet even when dry, although nectar does in fact ooze out of the pore in the staminal disc and accumulate on it. Nothing is known about the pollination biology of the species but the firm texture of the flowers and their yeasty odour suggest rodent pollination.

*Diagnosis and relationships*: *D. capensis* is readily distinguished from other species of *Daubenya* in which

the filaments are fused into a long, narrow column by the peculiar disc that occludes the mouth of the column and through which the style protrudes via a narrow pore. *D. capensis* is most similar in floral form to *D. alba*, which it also resembles in its distinctly pedicellate flowers and large, obtriangular capsules that are deeply retuse at the apex. The fruits in these two species are among the largest in the genus. *D. capensis* is readily distinguished from *D. alba* by its more robust, yellow flowers with shorter perianth tube, 6–10 mm long and by the conspicuous disc that occludes the mouth of the staminal tube.

*History*: *D. capensis* was first collected in July 1897 by the German botanist, Friedrich Richard Rudolf Schlechter and was described by him some years later, when it formed the basis of his monotypic genus *Androsiphon*. Here it remained until recently, when that genus was included in *Daubenya* (Goldblatt & Manning 2000).

*Conservation status*: Vulnerable (B1+2c, D).

7. *Daubenya stylosa* (W.F.Barker) A.M.van der Merwe & J.C.Manning, in Goldblatt & J.C.Manning in *Strelitzia* 9: 713 (2000).

*Amphisiphon stylosum* ['stylosa'] W.F.Barker: 19 (1936); Brandham: 58 (1989); U.Müll.-Doblies & D.Müll.-Doblies: 86 (1997). Type: South Africa, Northern Cape, Calvinia Dist., 3 miles north of Nieuwoudtville, 21 June 1934, *Salter 4552* (BOL, *holo.*!).

Bulb subglobose to turbinate, 20–35 mm diam., usually shallowly buried; outer tunics leathery, dark brown, extending in a papery neck up to 5 mm long. *Leaves* 2, suberect to spreading, ovate to lanceolate, (20–)50–100 × 15–50 mm, bases clasping peduncle for up to 30(–60) mm, dark green. *Inflorescence* subspicate, capitate or rarely conical, exerted up to 50 mm above leaves; bracts increasing in size acropetally, lowermost lanceolate, white, 3–5 mm long, uppermost oblanceolate, up to 8 × 3 mm; pedicels suberect, 1–3 mm long, flowers subsessile. *Flowers* greenish yellow with free part of filaments and style golden yellow, honey-scented; perianth tube cylindrical, 8–14 mm long in lower flowers with portion



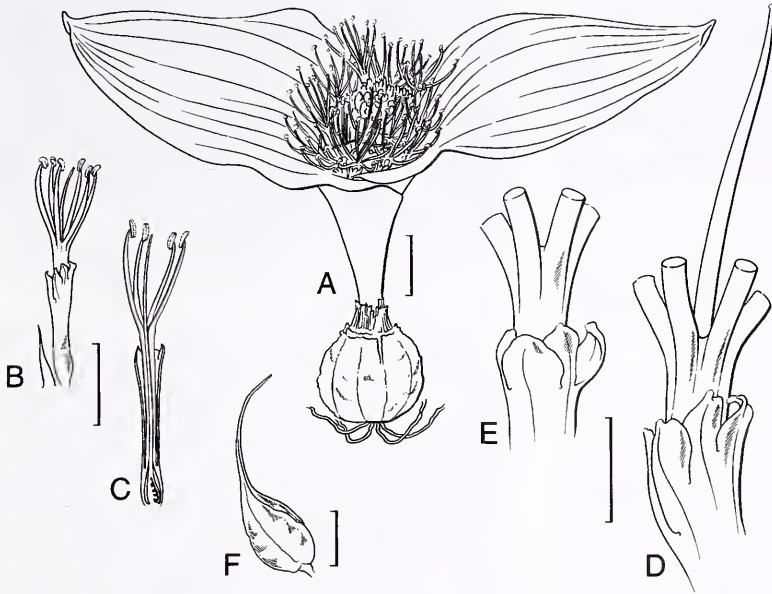


FIGURE 9.—*Daubenya stylosa*. A, whole plant. B–E, flower: B, with bract; C, l/s; D, tepal detail of lower part; E, tepal detail of upper part. F, capsule. Scale bars: A–C, F, 10 mm; D, E, 5 mm. Artist: John Manning.

below level of filament insertion 4–7 mm long but 6–8 mm long in upper flowers with portion below level of filament insertion 2–3 mm long, 2.0–2.5 mm diam.; lower flowers lightly bilabiate with adaxial portion of tube  $\pm$  3 mm longer than abaxial half through a greater degree of fusion of upper three tepals; tepals connate into tube above level of filament insertion, free parts oblong to ovate, 2–5 mm  $\times$  2.0–2.5 mm. *Stamens* fused below into tube 10–15 mm long, free parts of filaments suberect, 9–10 mm long; anthers yellow, up to 2.5 mm long before dehiscence. *Ovary* ovoid,  $\pm$  3 mm long; style reaching to top or just beyond filaments, 17–28 mm long. *Capsule* depressed-ovoid, 10–12  $\times$  7–10 mm, lightly retuse at base and tapering above into persistent style which forms slender beak  $\pm$  20 mm long, indehiscent but eventually separating along septa. *Seeds* globose,  $\pm$  2 mm diam., glossy black. *Flowering time*: mid May to mid June. Figure 9; Plate 1G.

**Distribution and ecology:** *Daubenya stylosa* is a highly local endemic around Nieuwoudtville where it is known from a few populations in the immediate vicinity of the town, especially along the trekpath that passes the Farm Glenlyon, at an altitude of 800 m (Figure 10). The populations here are extremely dense. The plants typically grow in lower-lying drainage areas in red doleritic clays. Scattered plants occur along the foot of dolerite outcrops on the Wildflower Reserve and on Glenlyon itself. The species is more or less sympatric with *D. capensis* but the two cannot be confused, either in flower or fruit. The compact infructescence in *D. stylosa* lacks the adaptations for wind dispersal typically found in most other species in the genus and the seeds are mainly shed immediately around the parent plants.

The sweetly scented, greenish yellow flowers secrete small amounts of nectar that ooze out of the mouth of the staminal column. They are visited avidly for the nectar by honeybees (*Apis mellifera*) and the Painted lady butterfly (*Cynthia cardui*) during the day and by several species of noctuid moth at dusk.

**Diagnosis and relationships:** the species is readily recognized by its almost completely fused tepals, which form a tube around the staminal column, and by the persistent styles that remain attached to the capsule. These stiff, prong-like beaks are a conspicuous feature of the subsessile fruits. In addition, unlike most other species in the genus, which have loculicidally dehiscent capsules, the fruits in *D. stylosa* are essentially indehiscent although the locules eventually separate along the septa to release the seeds.

**History:** *D. stylosa* was first collected relatively recently, in June 1934, by retired Royal Navy Paymaster, T.M. Salter, best known for his work on the genus *Oxalis*. It was described soon thereafter in the monotypic genus *Amphisiphon* by the Cape Town botanist W.F. Barker. Included in *Amphisiphon* by Phillips (1951), the genus was recently transferred to *Daubenya* (Goldblatt & Manning 2000).

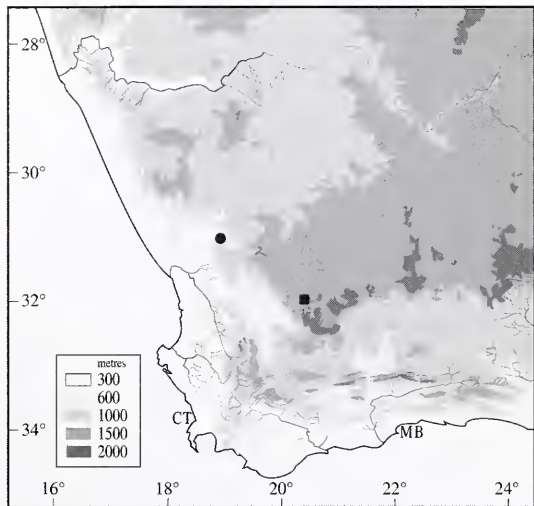


FIGURE 10.—Distribution of *Daubenya stylosa*, ●; *D. aurea*, ■.

*Conservation status:* Vulnerable (B1+2c, D).

8. ***Daubenya aurea* Lindl.** in Botanical Register 21: t. 1813 (1835); Kunth: 301 (1843); E. Phillips: t. 71 (1922b); Jessop: 431 (1976); U.Müll.-Doblies & D.Müll.-Doblies: 91–95 (1997). Type: South Africa, Cape, without locality or collector, cultivated by Messrs Young of Epsom (icono.!).

*Daubenya fulva* Lindl.: t. 53 (1839); Kunth: 300 (1843). Type: received from the Cape of Good Hope, with other bulbs, but [mistakenly] believed to have been collected somewhere on the East Coast of Africa or in Madagascar, cultivated by Robert Barchard, Wandsworth (CGE, holo.).

*Daubenya coccinea* Harv. ex Baker: 395 (1871). *D. aurea* Lindl. var. *coccinea* (Harv. ex Baker) Marloth in E. Phillips (1922b). Type: Caput Bonei Spei. *Harvey s.n.* (TCD, holo.).

Bulb subglobose to turbinate, 20–35 mm diam., usually shallowly buried; outer tunics leathery, dark brown, extending in a short, papery neck up to 10 mm long. *Leaves* 2, suberect to spreading, ovate to lanceolate, 50–100(–140) × 20–75 mm, bases clasping peduncle for 5–50 mm, dark green. *Inflorescence* corymbose, capitate, exerted up to 50 mm above leaves; bracts decreasing in size acropetally, greenish, lowermost obovate to oblanceolate, 25–35 × 10–15(–20) mm long, uppermost up to 20 × 10 mm; pedicels suberect, lowermost 5–10 long, uppermost up to 3 mm long. *Flowers* brilliant red or canary yellow, rarely flushed reddish at tips of tepals, at most lightly scented, ± zygomorphic and bilabiate; lower flowers strongly bilabiate with abaxial or lower half of tube much prolonged and adnate to filament column and lower three tepals forming conspicuous lip separated from upper tepals by pronounced sinus, sometimes dorsal or uppermost tepal arising very much below remaining tepals, perianth tube obliquely cylindrical, 15–25 mm long on upper side but 20–40 mm long on lower side, 3–4 mm diam., upper tepals oblong-ovate, laterals obliquely so, 2–4 × 1.5–2.0 mm, lower tepals oblanceolate to obovate, subequal or median larger, 20–40 × 5–15 mm; upper flowers weakly zygomorphic or actinomorphic, perianth tube 13–20 × 2.5–3.5 mm, tepals oblong,

2–4 × 1.5–2 mm. *Stamens* fused basally into an oblique tube, 5–7 mm long on adaxial side but much longer on abaxial side, especially in lower flowers, and there adnate to lower tepals such that lower stamens appear to be free, free parts of filaments suberect, 4–8 mm long; anthers yellow, 2.5–3.0 mm long before dehiscence. *Ovary* ovoid, 7–8 mm long; style reaching to top or just beyond all or only adaxial filaments, 20–25 mm long. *Capsule* oblong-ovoid, 3-angled, 15–20 × 7–10 mm, introrse at base but acute at apex. *Seeds* globose, ± 3 mm diam., glossy black. *Flowering time*: late August to mid September. Figure 11; Plate 1H.

*Distribution and ecology:* *D. aurea* is a highly localized endemic of the Roggeveld Escarpment known from three or four localities midway between Sutherland and Middelpos, at an altitude of ± 1 500 m (Figure 10). The known populations lie along the eastern foot of a meandering dolerite ridge, with the total distribution little more than 10 km in extent. The plants grow in colonies in low-lying drainage lines in seasonally damp red clay derived from dolerite. Populations are sympatric with *D. marginata* in several of the localities but flower much later than that species. *D. aurea* occurs in two colour forms, the more common one a brilliant red and the other canary yellow. Populations are typically uniformly coloured, although red populations will often contain occasional yellow morphs, whereas yellow populations may include a few plants in which the tepals are flushed reddish at the tips. The yellow populations consistently come into flower one or two weeks before the red but the fruits appear to take much longer to ripen. The prominent papery bracts that are characteristic of the species are particularly conspicuous in fruit, serving as sails that assist in the wind dispersal of the infructescences.

The inflorescence resembles a large daisy capitulum in the genus *Arctotis* or *Gazania* due to the enlargement of the lower florets, and the species is adapted to pollination by monkey beetles (Scarabidae: Holpiinae) that congregate on the large flower heads to mate. The flowers, unlike those of the other species in the genus, do not produce nectar and are also unscented or at most weakly



FIGURE 11.—*Daubenya aurea*. A, whole plant; B, lower flower and bract. C, D, upper flower; E, capsule. Scale bars: A–E, 10 mm. Artist: John Manning.



scented. Both of these characteristics are typical adaptations to pollination by monkey beetles.

**Diagnosis and relationships:** *D. aurea* is a highly distinctive species that cannot be confused with any other species in the genus. The highly zygomorphic lower flowers in which the outer tepals are greatly exaggerated in size make this species instantly recognizable. It is also characterized by large floral bracts that are persistent and papery in fruit.

**History:** it is ironic that the source of the original material of the best known species of *Daubentya* remained obscure for so long. *D. aurea* was described in 1835 by John Lindley, Professor of Botany at the University College, London and head of the Chelsea Physic Garden, from a yellow-flowered plant cultivated by the nurserymen, Messrs Young of Epsom. Nothing is known of its origin beyond that the Youngs obtained their plant from the Cape of Good Hope under the name *Massonia lutea*. Three years later a reddish-flowered variant of the species came to Lindley's attention through the agency of John Royle, then Professor of Materia Medica at King's College, London, from the collection of Robert Barchard of East Hill, Wandsworth. Lindley was struck by the apparently more extreme zygomorphy evident in the flowers of the red form and he recognized this collection as a different species, *D. fulva*, on this basis. The name is an allusion to the tawny colour of the plant, but this, along with the rather etiolated appearance of the plant, was probably the result of cultivation in less than ideal light. From the illustration it is clear that this plant was in fresher flower than the first one that Lindley had seen and he presumably examined only the lowest, most zygomorphic flowers in the inflorescence. This plant had been received from the Cape of Good Hope with other bulbs but was believed to have been collected somewhere along the East Coast of Africa or in Madagascar. This was, of course, not the case but it is possible that Barchard received his plant from the same source as did the Youngs. A dried plant of *D. fulva* was later seen by Baker (1897) in the herbarium of William Wilson Saunders, who had a notable garden at East Hill from 1857 to 1874 and was a neighbour of Barchard. It is thus probable that his specimen came from Barchard himself and is possibly even the one illustrated in the protologue. At the same time that Lindley was describing his two species of *Daubentya*, a specimen appears to have been in the possession of William Henry Harvey in Cape Town. Harvey, although nominally Colonial Treasurer, occupied most of the four years that he spent in Cape Town between 1835 and 1842 on botany. Harvey's specimen formed the basis of *D. coccinea*, described by Baker (1871), which was distinguished from *D. fulva* by its compact inflorescence and more robust flowers. Although the provenance of the plant is unknown, its appearance is typical of wild collected material or that grown under good light, such as would have been experienced in Cape Town. It is impossible to be certain on this point but the more or less coincidental appearance of material in three different hands strongly suggests that it all originated from the same source. Circumstantial evidence favours Capt Walter Synnot as this source. Synnot spent four years in Clanwilliam as deputy landrost, returning to Ireland in 1825 with numerous bulbs and

seeds. These were disposed of in England to various nurseries and included various species from the Bokkeveld and Roggeveld Escarpments, some of which only flowered in the 1830s. It is thus quite possible that among them were seeds or plants of *D. aurea*.

Almost a century was to pass without further information until, in 1920, Rudolph Marloth came upon *Daubentya aurea* in the wild on the Roggeveld Escarpment. Marloth, a retired chemist with a passionate interest in South African botany, sent plants and exact details of the locality and habitat to the Pretoria botanist, E.P. Phillips, who published the story of the rediscovery in 1922. At the same time it became evident that no significant structural differences existed between the three species hitherto known and they were consequently reduced to one. Although further plants were sent to Kirstenbosch gardens by a Mr Metelerkamp in 1936 (Hall 1970), they soon languished and it was left to Harry Hall, then Senior Horticulturalist at the Gardens, to locate Marloth's collecting site in 1968 and bring the species into cultivation once more. He has provided a lively account of his search, illustrated with fine photographs of the plants in the wild (Hall 1970).

**Conservation status:** Vulnerable (B1+2c, D).

#### *Specimens examined*

- Acocks 16344, 22097 (1) PRE. Archibald 3066, 3118 (1) PRE.  
 Barker 9736, 10179, 10237, 10244 (4) NBG; 6703 (2) NBG; 9366, 9389 (6) NBG; 9390, 10545 (7) NBG. Boucher 5153 (3) NBG.  
 Cloete & Haselau 96 (8) NBG. Coetzer 67 (3) NBG. Compton 702/28, 7470 (3) NBG; NBG1531/26 (6) NBG.  
 Hall 225, 3242, 4253 (3) NBG; 3240, s.n. (8) NBG; 3269 (8) NBG. PRE; 3276 (8) PRE. Harrower 305 (5) NBG. Heurici 3983 (1) PRE. Herman 530 (1) PRE.  
 Leipoldt 796 (6) NBG. Leistner 1900 (1) PRE; 2508 (2) KMG, M. PRE. Louw 1828 (1) BOL. PRE.  
 Manning 2175 (4) NBG; 2250 (2) NBG; 2263, 2343, s.n. (3) NBG; 2327, 2329 (1) NBG; 2345 (5) NBG; Marloth 10346 (8) PRE; 10415 (8) BOL; 10415 (8) NBG. PRE. McCarthy SAM23080 (1) SAM. Meiring BOL2775/15 (8) BOL. F.W. Meterlekamp 355/37 (8) NBG. Mostert 819 (1) PRE. Muller sub Marloth 9550 (8) PRE.  
 Oliver 4423, 9464 (3) NBG; 4412, 8932, 8972 (8). NBG.  
 Perry 3511 (8) NBG. Perry & Suijman 2132, 2143 (7) NBG.  
 Rossouw s.n. (3) NBG.  
 Saaijan 125 (1) PRE. Salter 1558/34 (7) NBG; 4452 (3) BOL. Schlechter 90 (2) SAM. BOL. Schlieben 9017 (2) BOL. BM. BR. M. PRE. Z. Suijman 1228, 1705 (7) NBG. Stayner s.n. (3) NBG. Steytler s.n. (4) NBG.  
 Thompson 2439, 3011, 3093 (3) NBG.  
 Van der Merwe 195 (5) NBG. Van Wyk 934 (1) PRE; 2578 (6) BOL; 2579 (7) BOL. Vlok 633 (6) NBG.  
 Wilman s.n. (1) BOL.  
 Zambatis 202 (1) PRE. Zietsman & Zietsman 1700 (1) PRE.

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# The genus *Trichodesma* (Boraginaceae: Boraginoideae) in southern Africa

E. RETIEF\* and A.E. VAN WYK\*\*

**Keywords:** Boraginaceae, Boraginoideae, morphology, pollen, southern Africa, taxonomy, *Trichodesma* R.Br., Trichodesmeae

## ABSTRACT

*Trichodesma* R.Br. is a genus of about 45 species known from tropical and subtropical regions of Africa, Asia and Australia. The group comprises predominantly perennial herbs, the flowers characterized by anthers with prolonged connectives, often twisting above the thecae, and a prominent accrescent calyx. Five species and three subspecies of *Trichodesma* are currently recognized in southern Africa, with *T. angustifolium* Harv. subsp. **argenteum** Retief & A.E.van Wyk newly described. These taxa are widespread in southern Africa, occurring in various vegetation types. A key to the species, descriptions, distribution maps and illustrations of various micro- and macromorphological as well as palynological features are provided.

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resented by five species and three subspecies in southern Africa; about 15 species occur in Africa south of the Sahara (Lebrun & Stork 1997). Members of *Trichodesma* are widespread in southern Africa and occur in various vegetation types, ranging from grassland and savanna (bushveld) to succulent shrubland.

The purpose of this paper is to present a taxonomic revision of the genus *Trichodesma* in southern Africa. Diagnostic characters, two keys, one based mainly on fruiting characters, the other on the leaf and flowering characters, full descriptions of all species and infraspecific taxa, illustrations and distribution maps are provided. The genus and species descriptions are based on material from southern Africa and the adjacent *Flora zambesiaca* (FZ) region. This paper forms part of a revision of the Boraginaceae currently in progress for the *Flora of southern Africa* (FSA) region, henceforth referred to as southern Africa.

## MATERIALS AND METHODS

Herbarium specimens of *Trichodesma* in BFLU, BM, BOL, COI, E, GRA, J, K, NBG, NH, NMB, NU, PRE, PRU, SAM and WIND (acronyms as in Holmgren *et al.* 1981) were examined to gather data on morphological characters, phenology and distribution. Specimens of taxa occurring outside southern Africa that were examined, are not cited. This was supplemented by field work which included observations on the effect of fire on plants of *T. physaloides* in the Pretoria National Botanical Garden, where this species occurs naturally. Pollen and various plant parts were studied with an ISI-SX-25 scanning electron microscope. Measurements of pollen grains were done from acetolysed grains mounted in glycerine jelly. Acetolysis followed the standard method of Erdtman (1960).

## INTRODUCTION

Brown described *Trichodesma* in 1810, a genus well defined by flowers with a deeply divided and strongly accrescent calyx, the absence of fornicies, anthers usually with fairly long, soft hairs on the back and conspicuous long, linear, often twisted connectives produced above the thecae. It belongs to the family Boraginaceae established by Jussieu (1789), and subfamily Boraginoideae. This family is characterized amongst others, by coiled, cymose inflorescences, setae with multicellular bases and in most genera, fruit that develop into four nutlets.

The genus *Trichodesma* R.Br. comprises ± 45 species, known from tropical and subtropical regions of Africa, Asia and Australia (Mabberley 1997). It is currently rep-

## HISTORICAL OUTLINE

Brown (1810) based his concept and description of *Trichodesma* on *Borago zeylanica* Burm.f. and *B.*

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*africanum* L. When De Candolle (1846) revised the genus, he recognized eight species. In the description of *T. africanum*, De Candolle mentioned that it was collected by Thunberg and by Drège in the 'Cape of Good Hope', the first southern African record for the genus. De Candolle also included *Friedrichsthalia physaloides* Fenzl, a species previously described from the Sudan. Wright (1904) noted that *T. physaloides* (Fenzl) A.DC. also occurred in the Transvaal, South Africa. He added a third southern African species, *T. angustifolium*, described by Harvey (1859), but was not aware of *T. zeylanicum* (Burm.f.) R.Br., today also known from southern Africa, although originally described from Sri Lanka (Ceylon), and most probably introduced to the region by man. Two species, *T. africanum* and *T. angustifolium*, were recognized in the flora of South West Africa (now Namibia) by Friedrich-Holthammer (1967). Herman (1993) listed five species and a subspecies for southern Africa, namely *T. africanum*, *T. angustifolium*, *T. arenicola* Gürke, *T. physaloides*, *T. zeylanicum* and *T. ambacense* Welw. subsp. *hockii* (De Wild.) Brummitt. However, specimens from southern Africa previously identified as *T. arenicola*, proved to be *T. ambacense* Welw. subsp. *hockii*. In the present paper we recognize five species and three subspecies of *Trichodesma* in southern Africa, namely *T. africanum* (L.) Lehm., *T. ambacense* Welw. subsp. *hockii* (De Wild.) Brummitt, *T. angustifolium* Harv. subsp. *angustifolium*, *T. angustifolium* Harv. subsp. *argenteum* Retief & A.E. van Wyk subsp. nov., *T. physaloides* (Fenzl) A.DC. and *T. zeylanicum* (Burm.f.) R.Br. Brummitt (1990), in his account on *Trichodesma* for the Flora zambesiaca (FZ) region, recognized the same species for the FZ region except for *T. africanum*, a species with a disjunct distribution between the FSA region, Angola and North Africa, and which is not known in the region. *T. zeylanicum*, *T. physaloides* and *T. ambacense* extend further north into Africa, supplemented by other species (Verdcourt 1991).

#### TRIBAL DELIMITATION

De Candolle (1846) assigned *Trichodesma* to the tribe 'Borragaeae' and subtribe Cynoglosseae, a classification followed by most subsequent authors, for example Hooker (1885), Gürke (1897), Baker & Wright (1905), Brand (1921), Melchior (1964) and Hilger (1985). In 1941 Zakirov placed *Trichodesma* in a tribe of its own, Trichodesmeae, recognized by Riedl (1967) and is also accepted in the present contribution. *Trichodesma* is well defined by a combination of floral and palynological characters: deeply divided and strongly accrescent calyx; the absence of fornicies in the corolla tube; anthers that usually have fairly long, soft hairs on the back; and conspicuous long, linear, often twisted connectives above the thecae. Pollen of the genus shows essentially no interspecific differences, is isopolar, tricolporate and with a nodular tectum. This pollen type is strikingly different from that of most genera of the tribe Cynoglosseae in which the grains are heterocolpate and the tectum psilate (Retief & Van Wyk 1999a, b). Avetisian (1956) agreed with Zakirov in removing *Trichodesma* from the tribe Cynoglosseae, based on the structure of its flowers and fruits, because the pollen grains of the genus have nothing in common with those of the Cynoglosseae.

Pollen morphology thus strongly supports the recognition of the separate tribe, Trichodesmeae.

Members of *Trichodesma* differ significantly from each other in outlet morphology (see note on fruit morphology). However, the presence of glochidia on the outer surface of the outlets of *T. africanum* and *T. angustifolium* could be used to argue that the placement of *Trichodesma* in its own tribe is not justified, because glochidia also occur on the outer outlet surface of *Cynoglossum* and *Afrotysonia*. The types of glochidia found in *Trichodesma*, however, differ from those of *Cynoglossum* and *Afrotysonia*. Hilger (1985) studied the development and morphology of flowers and fruits of 23 species of the Cynoglosseae and Eritrichieae, and commented on the implications of his findings on the taxonomy of these groups. He found that in most Cynoglosseae the outlets are initially positioned with their disc (the flat base) parallel to the basal area (the nectary disc) of the gynoeceum. Subsequent growth in a vertical direction brings the outlets to their final oblique position. In both species of *Trichodesma* studied by Hilger, he observed that the outlets are, from the beginning, in an oblique position. This can also be used to support the recognition of a separate tribe for this genus.

Two other genera are assigned to the tribe Trichodesmeae, namely *Caccinia* Savi and *Suchtelenia* Kar. ex Meisn. (Riedl 1967). Gürke (1897) separated five genera using the accrescent calyx, either enclosing the fruit or expanded, as the key character: *Trichodesma*, *Suchtelenia*, *Caccinia*, *Brachybotrys* Maxim. ex Oliv. and *Heliocarya* Bunge. *Heliocarya* is regarded as congeneric with *Caccinia* (Mabberley 1997) and *Brachybotrys* belongs to the tribe Trigonotideae (Riedl 1997). *Suchtelenia* has 6-heterocolpate pollen grains, showing similarity to pollen of members of Heliotropioideae, Cynoglosseae, Eritrichieae and Myosotidae. The triaperturate pollen grains of *Trichodesma* and *Caccinia*, on the other hand, show similarity to pollen of the subfamilies Wellstedioideae and Ehretioideae. The tribe Trichodesmeae can be regarded as 'primitive' within the subfamily Boraginoideae, showing similarities to various other genera within the Boraginaceae *s.l.* The family is sometimes treated as two separate entities, Boraginaceae *s. str.* and Ehretiaceae, but various characteristics support the recognition of one family divided into several subfamilies (Retief & Van Wyk 1999c).

#### MORPHOLOGICAL CHARACTERS OF TAXONOMIC SIGNIFICANCE

##### *Habit*

*Trichodesma* is a genus of perennial and annual herbs or subshrubs. *T. africanum* is the only southern African species that is usually annual or occasionally biennial. This growth form can be correlated with its distribution in arid and desert regions where fast growth under optimal conditions is essential.

The other species are perennial herbs or subshrubs occurring in summer rainfall regions, mainly in grassland and savanna. They are subjected to winter drought and



also to regular natural fires and frost. Grassland species are usually quick in responding to the effects of fire (smoke, change in temperature and the release of nutrients), and plants may sprout a number of inflorescences. With sturdy, often very old, fire-resistant rootstocks and mass seed production by fire-stimulated flowering, these species are well-adapted to survive unfavourable conditions. Most examples of fire-stimulated flowering plants do flower in the absence of fire, but not as profusely as when subjected to fire. It was, however, observed that unburned plants of *T. physaloides* did not flower at all or produced only a few inflorescences, as opposed to burned plants of the species in the same grassland that sprouted and produced inflorescences abundantly after a natural fire (Figure 1A, B). Burning of this particular piece of grassland under controlled circumstances to remove moribund and/or unacceptable grass material had no effect on the number of flowers produced, because the intensity of the fire was too low. A cool or low-intensity fire of less than 1 000 kJ/s/m is usually applied (Trollope 1992).

### Leaf

Intraspecific taxa of *Trichodesma* differ remarkably in the indumentum of the leaf blade. The leaf trichome complement of the southern African members of *Trichodesma* consists of setae with multicellular bases, and simple, unbranched hairs. *T. physaloides* and *T. ambacense* subsp. *hockii* have flat, large-based setae, but differ in the structure of the setae (Figure 2A, B, D, E). *T. ambacense* subsp. *hockii* (Figure 2D) has slender setae, orientated in different directions, whereas *T. physaloides* (Figure 2E) has shorter, attenuate setae, orientated more or less in a direction parallel to the midrib. Upper leaf surfaces of the taxa concerned are relatively densely hairy (Figure 2A, C, H), whereas the lower leaf surfaces of *T. physaloides* (Figure 2B), *T. ambacense* subsp. *hockii*, *T. angustifolium* subsp. *angustifolium* and *T. africanum* (Figure 2I) are sparsely hairy, with setae scattered on the midribs and along the veins. *T. angustifolium* subsp. *angustifolium* is characterized by an indumentum of appressed setae, orientated in a direction parallel to the midrib and varying in length and in size at the base, with distinct spaces between the trichomes. The

leaf surfaces of *T. angustifolium* subsp. *argenteum* (Figure 2C, F) are silver-grey, covered with a dense layer of setae on both surfaces, a feature distinguishing this taxon from all other southern African taxa of *Trichodesma*. The outline of the multicellular bases of the setae is not circular, but slightly asymmetrical.

Leaves of *T. zeylanicum* (Figure 2G) are characterized by a lower surface that is densely hairy, with mainly simple, small hairs, but also with scattered setae along the midrib and some veins. The upper surface is covered by setae of which the large, 2-layered multicellular bases are  $\pm$  circular in outline, with much smaller setae in between (Figure 2H). *T. africanum* has a spinose indumentum with stiff setae on the lower surface (Figure 2I). Cells of the multicellular base of the setae are narrower compared to those of *T. zeylanicum*. The upper surface of *T. africanum* is characterized by well-spaced setae with a prominent row of swollen cells at the point where the seta and multicellular base join. Cells of the multicellular bases of the older leaves are impregnated with silica and some calcium, giving them a spotted appearance.

### Flower

Various flower characters in *Trichodesma* are taxonomically significant. Anthers with connectives lengthening into usually twisted appendages above the thecae, distinguish the genus from all other southern African members of the family (Figure 3A, B). Long, shaggy hairs (Figure 3A, C, F) are present on the dorsal surfaces of the connectives, whereas the inside of the thecae are glabrous (Figure 3F). The subglobose stigma displays two types of receptive surfaces (Figure 3D, E, G, H). *T. angustifolium* has papillae with prominent contiguous caps (distal swellings) and crenulate margins (Figure 3D, E). Papillae without distinct caps occur in the other taxa studied (Figure 3G, H). Corolla lobes are often twisted (Figure 3I) and acuminate to long-acuminate. The colour of the lobes is usually shades of blue except for *T. physaloides* which has white lobes with a brownish rim.

A prominent feature of the flower in *Trichodesma* is the calyx which is strongly accrescent when in fruit



FIGURE 1.—*Trichodesma physaloides*. A, plant in unburned grassland; B, plant flowering abundantly after a natural veld fire.



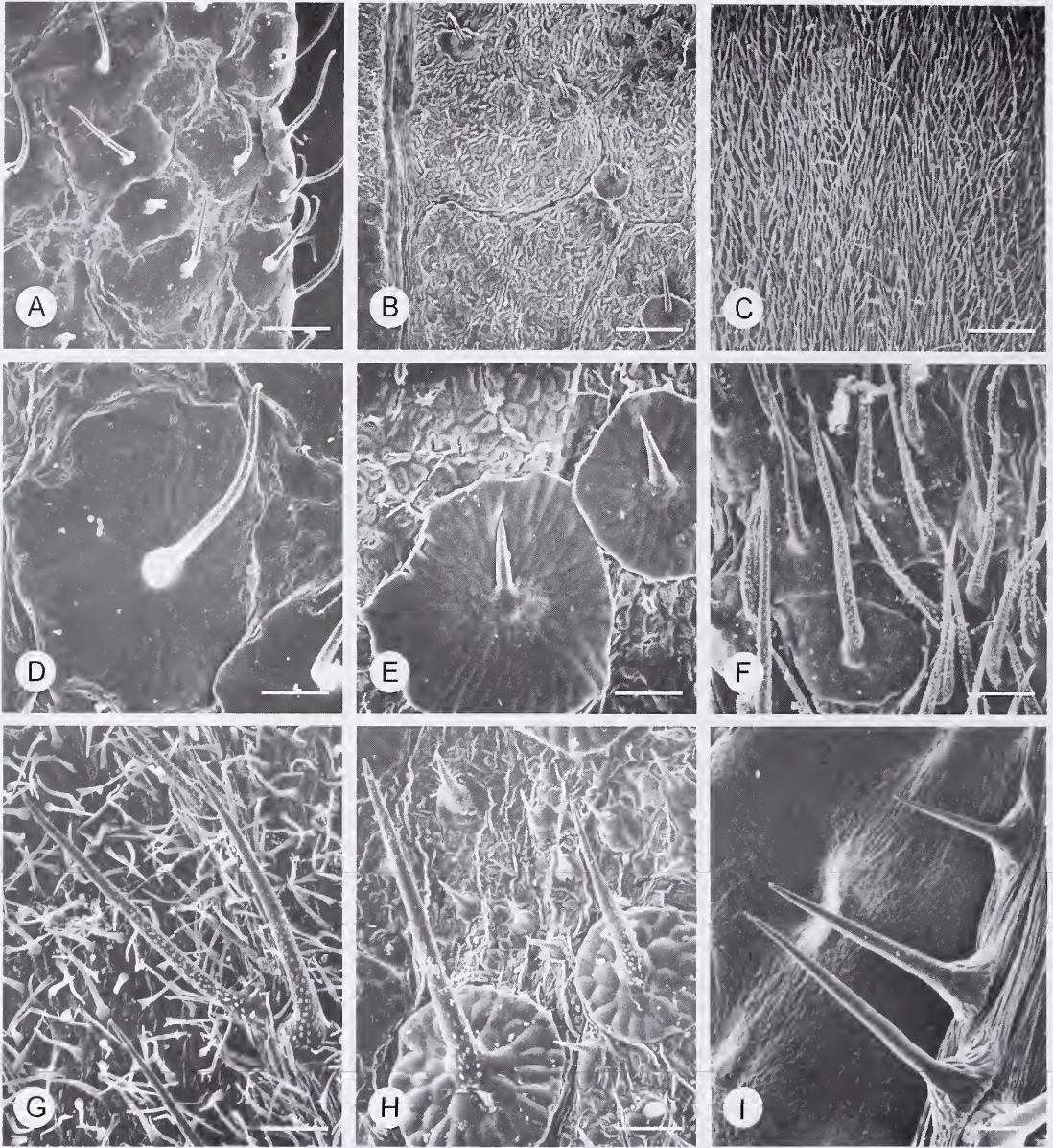


FIGURE 2.—*Trichodesma* leaf surfaces. A, *Trichodesma ambacense* subsp. *hockii*, Schoenfelder 159, upper surface; B, *T. physaloides*, Jacobsen 1813, lower surface; C, *T. angustifolium* subsp. *argenteum*, Retief 1404.01, upper surface; D, *T. ambacense* subsp. *hockii*, Schoenfelder 159, setae, slightly hooked, on upper surface; E, *T. physaloides*, Onderstall 1248, stiff setae on upper surface; F, *T. angustifolium* subsp. *argenteum*, Retief 1404.01, slender setae on upper surface. G, H, *T. zeylanicum*, Stalmans 1076: G, lower surface; H, upper surface. I, *T. africanum*, Smook 7695, stiff setae on midrib of lower surface. Scale bars: A, 18  $\mu$ m; B, 11  $\mu$ m; C, 8  $\mu$ m; D, 49  $\mu$ m; E, 26  $\mu$ m; F, 51  $\mu$ m; H, 2  $\mu$ m; I, 37  $\mu$ m.

(Figure 4). *T. physaloides* and *T. ambacense* subsp. *hockii* are characterized by a single mature nutlet with a persistent style. The style is initially gynobasic, but due to abortion of three ovules, it becomes orientated sideways. These single nutlets, together with the calyx and style are shed from the plant. This type of nutlet dispersal also occurs in *Cryptantha flava* (A.Nels.) Payson, another member of the Boraginaceae. According to Casper & Wiens (1981), the abortion of three of the four ovules may be an adaptation for dispersal by wind, the entire floral structure serving as a relatively light disper-

sal unit. The attached, accrescent, papery calyx may augment the buoyancy of nutlets in air currents and increase the dispersal distance. In the case of *T. africanum* it can be speculated that the spinose indumentum of the calyx protects the nutlets, allowing them to mature before any damage can be done by herbivores.

#### Pollen

Pollen studies revealed no significant differences between the species of *Trichodesma* included in this



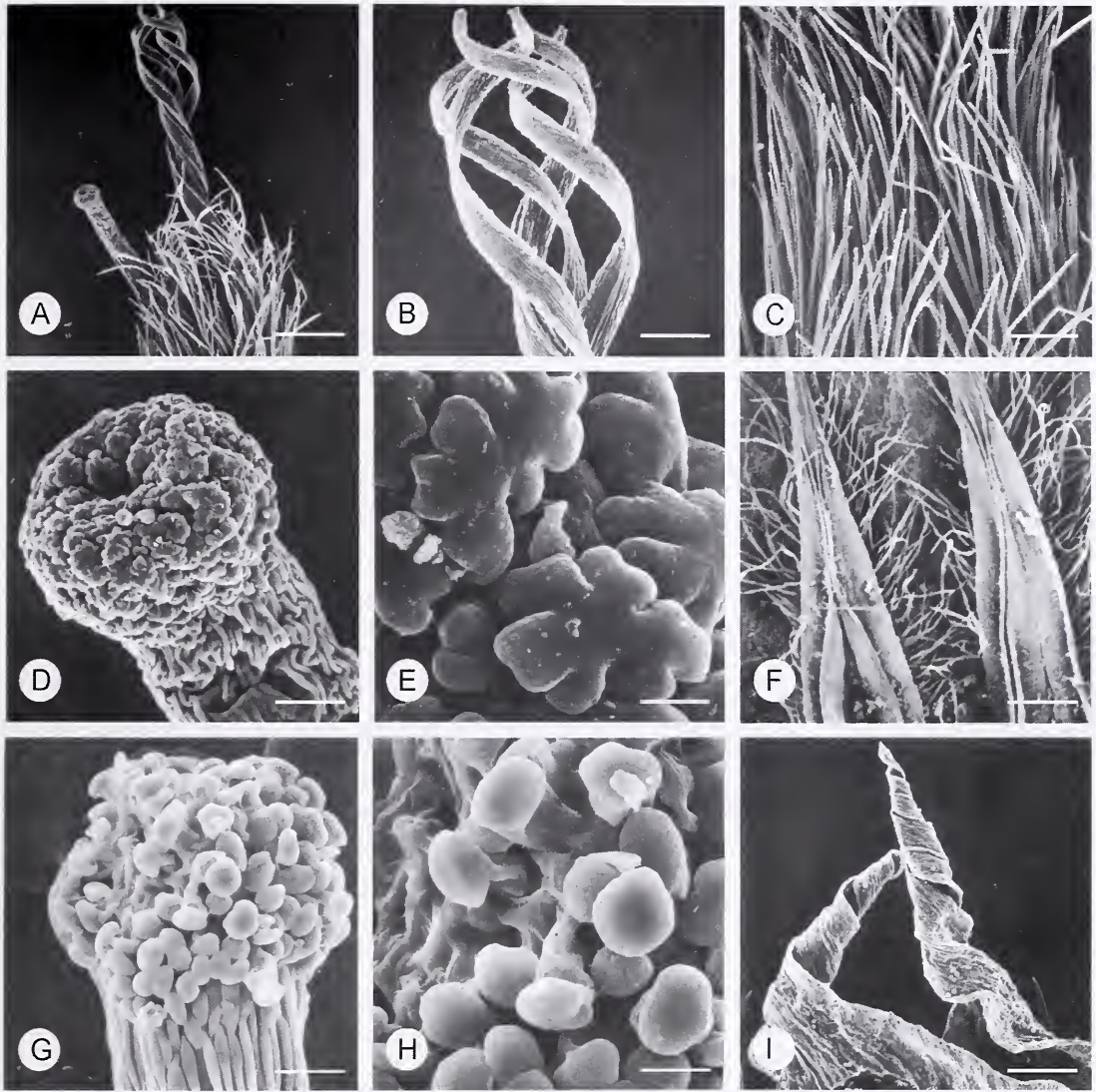


FIGURE 3.—*Trichodesma* flower parts. A–E, *Trichodesma angustifolium* subsp. *angustifolium*, Peeters, Gericke & Burelli 163: A, style, stigma and upper parts of anthers; B, twisted connectives; C, hairs on back of anthers; D, stigma; E, papillae. F, *T. physaloides*, Fourie 2804, section of two anthers. G–I, *T. africanum*, Germishuizen 4575: G, stigma; H, papillae; I, twisted apices of corolla lobes. Scale bars: A, 375  $\mu$ m; B, 178  $\mu$ m; C, 264  $\mu$ m; D, 51  $\mu$ m; E, 8  $\mu$ m; F, 750  $\mu$ m; G, 40  $\mu$ m; H, 18  $\mu$ m; I, 259  $\mu$ m.

study, a finding that is in agreement with Brummitt (1982). Pollen grains of the genus are isopolar, radially symmetrical, tricolporate, subspheroidal, with  $P = 7.0\text{--}11.5\text{ }\mu\text{m}$ ,  $E = 6.0\text{--}9.5\text{ }\mu\text{m}$ ,  $P/E = 1.1\text{--}1.2$  (Figure 5A–F). The shape of the pollen grains in polar view is  $\pm$  triangular, with convex mesocolpia and sunken apertures (Figure 5B). The equatorial view is elliptic to rounded with protruding ora; grains are angulaperturate (Figure 5A, C). Long apertures, extending over about  $4/5$  of the length of the polar axis, are characteristic of the grains. They are comparatively narrow with acute ends and the margins are not conspicuously different. Ora are coarsely granular, with endo-apertures lalongate (Figure 5D). The tectum is nodular with nodules  $\pm$  of the same size (Figure 5E), sometimes absent in the vicinity of the ora (Figure 5C, D). As noted in the discussion on the tribal delimitation of the genus, some authors prefer to classify

*Trichodesma* in the tribe Cynoglosseae but the tricolporate pollen of the genus supports its placement in the separate tribe Trichodesmeae. Pollen grains of members of the tribe Cynoglosseae are usually heterocolpate, quite different from those of *Trichodesma*. The similarity in pollen morphology between *Trichodesma* and *Cordia*, does not support the separation of the Boraginaceae into two separate families (Retief & Van Wyk 1999a).

#### Fruit

In Boraginaceae fruit characters are often used to distinguish species. Brand (1921) recognized six sections in *Trichodesma*, based on the outer surface morphology of the nutlets. Members of four sections are present in southern Africa, similar to the diversity reported by Verdcourt (1991) for East Africa. *T. physaloides* and *T.*





FIGURE 4—*Trichodesma physaloides*. Mature fruit and accrescent calyx,  $\times 1$ . Retief 2223 (PRE).

*ambacense* subsp. *hockii* (sect. *Friedrichsthalia* (Fenzl) A.DC.) are characterized by a single,  $\pm$  circular, cushion-

shaped, silken-haired nutlet (Figures 4; 6A; 10E). Nutlets of *T. physaloides* are covered with thin attenuate hairs (Figure 6B), whereas those of *T. ambacense* var. *hockii* have an indumentum of hooked hairs (Figure 6C). The other species have a fruit of four nutlets and are divided into two groups. Nutlets of *T. zeylanicum* (sect. *Trichodesma*) are emarginate and smooth on the outer face (Figure 6F), but rugose on the inner face. *T. angustifolium* (sect. *Acanthocaryum* Brand) and *T. africanum* (sect. *Serraticaryum* Verdc.) are characterized by the presence of glochidia (Figure 6D, E, G). The glochidia differ, however, in structure (Figure 6E, G). *T. angustifolium* is characterized by much smaller barbs than *T. africanum*. Nutlets of *T. africanum* are ovoid-cup-shaped with distinct, serrate, raised margins and a concave, glochidiate inner face (Figure 6G, H). The family Boraginaceae is characterized by flat, conical or pyramidal gynobases as e.g. in *T. africanum* where the gynobase is pyramidal (Figure 6I).

#### PHYTOGEOGRAPHY

*Trichodesma* is widespread in southern Africa (Figure 7) where members occur in various vegetation types,

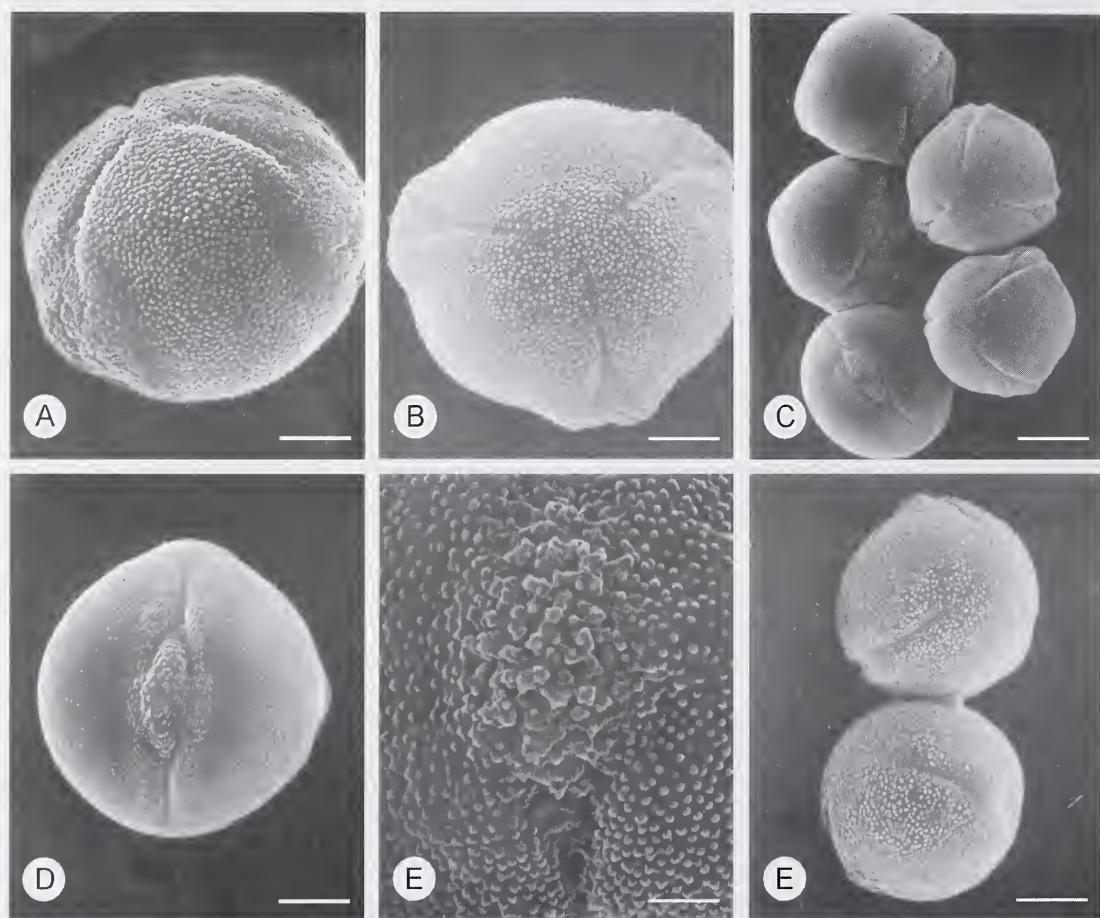


FIGURE 5.—*Trichodesma* pollen. A–E: unacetolysed, F, acetolysed. A, B, *T. africanum*. A, Germishuizen 4575, side view; B, Nicholas 2576, polar view. C, D, *T. zeylanicum*, Strey 5656: C, group; D, equatorial view of grain. E, *T. angustifolium* subsp. *angustifolium*, Hanekom 1498, tectum; F, *T. ambacense* subsp. *hockii*, Codd 7416, group. Scale bars: A, B, 2.8  $\mu$ m; C, 6.5  $\mu$ m; D, 3.2  $\mu$ m; E, 1.0  $\mu$ m; F, 4.8  $\mu$ m.

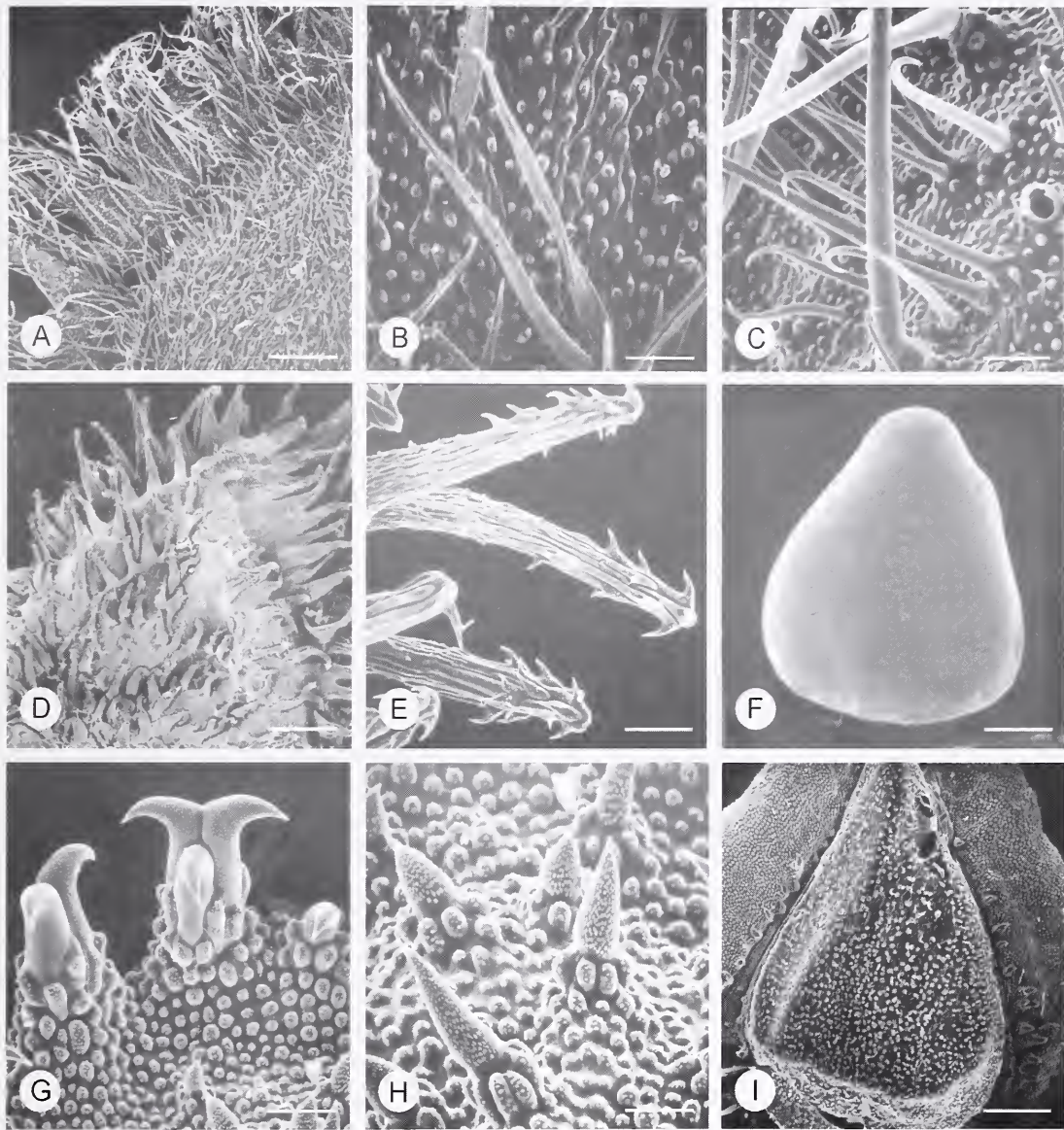


FIGURE 6.—*Trichodesma* nutlet surfaces. A, *T. physaloides*, JBG6150, margin; B, hairs; C, *T. ambacense* subsp. *hockii*, Schoenfelder 159, hooked hairs. D, E, *T. angustifolium* subsp. *angustifolium*: D, Gerstner 5133, glochidiate surface; E, Hanekom 1498, glochidia. F, *T. zeylanicum*, Netshingani 915, smooth nutlet. G–I, *T. africanum*: G, Bengis 463, margin with glochidia; H, Bengis 463, setae on dorsal surface; I, Van Jaarsveld 8825, pyramidal gynobase, one nutlet removed. Scale bars: A, 838  $\mu$ m; B, C, 84  $\mu$ m; D, 749  $\mu$ m; E, 131  $\mu$ m; F, 713  $\mu$ m; G, 79  $\mu$ m; H, 49  $\mu$ m; I, 419  $\mu$ m.

ranging from grassland and savanna to succulent shrubland, mainly in the Savanna and Grassland Biomes. All southern African species extend further north into Africa.

*Trichodesma angustifolium* subsp. *argenteum*, occurring in the northern parts of Namibia, is the only taxon endemic to the FSA region. Brummitt (1985) described a new *Trichodesma* species from the volcanic regions of Kenya, *T. marsabiticum* Brummitt, which is very similar in facies to *T. angustifolium*, and can be regarded as a vicariant of the southern African species, which differs in calyx and corolla characters. *T. angustifolium* subsp. *angustifolium* itself is disjunct in distribution in southern

Africa (Figure 9), and its current occurrences may represent relicts of a once much wider distribution. Brummitt (1985) considered that an early record of the species from Bulawayo in Zimbabwe should be disregarded unless modern collections can substantiate it.

The floristic connection between the dry areas of southern Africa, especially Namibia, and northeastern tropical Africa is well known, and is ascribed to a so-called arid corridor which connected the two regions at various times in the past (Verdcourt 1969; De Winter 1971; Thulin & Johansson 1996). *T. africanum* and *T. angustifolium* are examples of species confined to arid



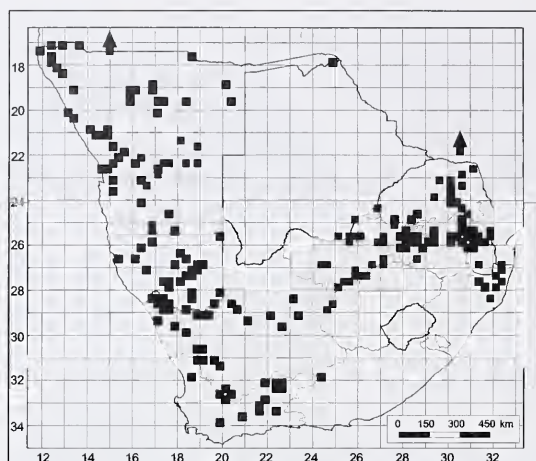


FIGURE 7.—Distribution of *Trichodesma* in southern Africa.

climatic conditions: in Africa it is known from arid parts of southern Africa, Angola and North Africa, thus belonging to the disjunct Afro-arid element.

The genus *Trichodesma* occurs in all six phytogeographical regions of southern Africa recognized by White (1983): Zambesian region, Kalahari-Highveld Transition Zone, Karoo-Namib Region, Tongaland-Pondoland Region, Afromontane Region and Cape Region. *T. physaloides* occurs mainly in the Afromontane floristic region which extends from the northern parts of Africa to southern Africa along the eastern mountain ranges. The Afromontane region comprises a series of isolated highland areas and is well represented in eastern Africa from Yemen to South Africa, but is also present in the Cameroon (Denys 1980). The region in southern Africa is characterized by numerous small forest patches in a grassland or fynbos matrix. The edges, or ecotones between forests and grasslands are usually sharp (typically just over a few metres) and are mainly maintained by both natural and more anthropogenic fires. *T. ambacense* subsp. *hockii*, closely related to *T. physaloides*, is found in some regions where *T. physaloides* occurs but is also found in regions such as Nigeria (see Brummitt 1985).

*Trichodesma zeylanicum* is an ancient Old World weed of human cultivation, introduced in southern Africa,  $\pm$  1905. It is no longer possible to distinguish natural occurrences of this species from introductions, hence its original native region is uncertain. *T. zeylanicum* occurs in grassland, woodland, in dry river beds, is a common weed in old and new cultivated land, a pioneer in disturbed areas, and is found along roadsides. The species is known from Namibia (Caprivi), the eastern parts of Northern Province, Mpumalanga, Swaziland and northern KwaZulu-Natal.

#### TAXONOMIC TREATMENT

*Trichodesma* R.Br., *Prodromus florae novae hollandiae*: 496 (1810), nom. conserv.; Harv.: 241 (1838); A.DC: 172 (1846); Benth.: 845 (1876); Hook.f.: 153

(1885); Gürke: 99 (1897); C.H.Wright: 10 (1904); Baker & C.H.Wright: 44 (1905); Brand: 19 (1921); E.Phillips: 628 (1951); Friedr.-Holzh.: 2 (1967); Riedl: 219 (1967); Kazmi: 515 (1971); Taton: 36 (1971); Kabuye & Agnew: 520 (1974); S.P.Banerjee & Pramanik: 109 (1975); R.A.Dyer: 510 (1975); J.R.Edm.: 435 (1978); Qaiser: 31 (1979); Tölken: 1172 (1986); Brummitt: 94 (1990); Nowicke & J.S.Mill.: 24 (1991); Verdc.: 91 (1991); E.S.Martins & Brummitt: 61 (1993); Riedl: 124 (1997); Retief: 182 (2000). Type: *Trichodesma zeylanicum* (Burm.f.) R.Br. (= *Borago zeylanica* Burm.f.)

*Boraginoides* Boehm.: 18 (1760). *Pollichia* Medik.: 247 (1783); non *Pollichia* Aiton: 5 (1789). *Boraginella* Kuntze: 435 (1891). Type: *Borago indica* L.

*Friedrichsthalia* Fenzl: 53 (1839). Type: *Friedrichsthalia physaloides* Fenzl.

*Leiocarya* Hochst.: 30 (1844). Type: *Leiocarya kotschyana* Hochst.

Annual and perennial herbs, often with annual stems from a woody rootstock, variously hairy. *Leaves* simple, opposite, subopposite or alternate, basal leaves usually opposite and petiolate, upper ones alternate and sessile or all leaves sessile, diminishing in size towards inflorescences; blade variously shaped, entire; stipules absent. *Inflorescence* a scorpioid, cymose panicle, bracteate, usually terminal. *Flowers* bisexual, regular, pedicellate, calyx, corolla and stamens usually 5-merous. *Calyx* deeply divided to base or lobes loosely adherent along lower margin, finely setulose on abaxial side, variously hairy on adaxial side; lobes ovate or narrowly ovate, sometimes winged, base rounded to cordate, apex acute, acuminate or cuspidate, strongly accrescent and papery in fruit. *Corolla* blue or white; tube campanulate or funnel-shaped, naked in throat, but with gibbosities between lobe sinuses; lobes ovate to broadly triangular, apex truncate or acute to acuminate, sometimes cuspidate, often spreading or reflexed. *Stamens* arising from base or from throat of corolla tube, sessile or filaments shorter than 1 mm and broader than long; anthers linear-oblong or linear-lanceolate, with long hairs on back, connectives prolonged above anthers, often twisted together at apex, usually exserted. *Ovary* 4-lobed, with a single ovule in each loculus; style persistent, gynobasic, terete, narrowing above; stigma subglobose, papillate, papillae with or without distinct caps, caps with crenulate margins. *Fruit* either 4 nutlets or by abortion 1; nutlets ovoid, planoconvex or biconvex, smooth or variously ornamented.

The name *Trichodesma* alludes to the twisted hairs or awns that terminate the anthers; Greek *thrix*, *trikhos* = hair and *desme* = a band or bundle (Tölken 1986).

Brand (1921) divided the genus into six sections but his taxonomy and nomenclature have been queried since. Some of the rather striking differences could be considered almost of generic importance (Verdcourt 1991), but we found no supporting palynological differences to justify this view in agreement with Brummitt (1982). Five species and three subspecies are recognized in southern Africa. Southern African species of *Trichodesma* represent the following four sections:



Sect. **Trichodesma**; Riedl: 225 (1967).

Sect. **Acanthocaryum** Brand: 27 (1921).

Fruit of four emarginate, smooth, shining nutlets, gynobase pyramidal with four strongly concave sides, each with  $\pm$  winged margin; nutlets compressed-ovoid, outer face usually mottled with grey and brown, inner face rugose, covered with indistinct papillae (*T. zeylanicum*).

Sect. **Serraticaryum** Verdc.: 92 (1991) (sect. *Friedrichsthalia* Brand non (Fenzl) A.DC.).

Fruit of four nutlets, ovoid-cup-shaped with distinct serrate margins and glochidiate hairs on outer face, i.e. base of cup; outer face convex, inner face concave, serrate margin also with glochidia; gynobase pyramidal with four strongly concave sides, each with  $\pm$  winged margin, verrucose (*T. africanum*).

Fruit of four nutlets, glochidiate, marginal glochidia usually coalescing at bases to form distinct rim; gynobase pyramidal with four strong concave sides, each with  $\pm$  winged margin; nutlets compressed-ovoid (*T. angustifolium*). Brummitt (1992) suggested that this section might be combined with sect. *Friedrichsthalia* Brand non (Fenzl) A.DC., now sect. *Serraticaryum* Verdc.

Sect. **Friedrichsthalia** (Fenzl) A.DC.: 173 (1846).

Fruit a single,  $\pm$  circular, cushion-shaped, silken-haired nutlet, concealed in accrescent calyx until released, attached by most of its lower surface to receptacle; gynobase flat; style persistent, lateral (*T. ambacense* subsp. *hockii*, *T. physaloides*).

Key to species  
(based on fruiting characters)

- 1a Fruit of four nutlets:
  - 2a Nutlet with outer surface smooth and shiny; lower leaf blade surface with setae only along midrib and veins, intercostal surfaces with dense cover of small bulbous-based hairs, orientated in different directions, upper leaf blade surface covered with long and much smaller setae in between ..... 1. *T. zeylanicum*
  - 2b Nutlet with outer surface glochidiate; indumentum of leaf blade not as above:
    - 3a Glochidia thick, mainly along serrate, raised margin of nutlet, thick short setae on dorsal side of nutlet; leaf blade ovate to narrowly ovate, lower surface with tubercle-based, stiff setae usually only along midrib and veins, upper surface with well-spaced, discoid-based setae ..... 2. *T. africanum*
    - 3b Glochidia slender, covering whole surface of nutlet; leaf blade linear to narrowly elliptic, lower and upper surfaces with well- to densely spaced, discoid-based, slender setae ..... 3. *T. angustifolium*
- 1b Fruit a single nutlet:
  - 4a Corolla lobes white with a light brown rim, rounded to truncate with short cuspidate apices; lower leaf blade surface with short, stiff, discoid-based setae scattered on midrib and veins, upper leaf blade covered with similar setae well spaced ..... 4. *T. physaloides*
  - 4b Corolla lobes blue or rarely whitish,  $\pm$  triangular, with long acute apices; lower and upper leaf blade surfaces with broad, discoid-based, slender setae, well spaced ..... 5. *T. ambacense*

Key to species  
(based on leaf and flower characters)

- 1a Leaf blade linear to narrowly elliptic ..... 3. *T. angustifolium*
- 1b Leaf blade broadly ovate, ovate, narrowly ovate or elliptic:
  - 2a Corolla lobes scarcely spreading when fully developed, rounded to truncate, cuspidate white and with a brownish rim; leaf blade sparsely hairy with stiff, short setae ..... 4. *T. physaloides*
  - 2b Corolla lobes reflexed over calyx when fully developed, acute to acuminate at apices, blue or rarely whitish, not with a brownish rim; leaf blade hairy, setae slender:
    - 3a Accrescent calyx lobes cordate at base,  $\pm$  22  $\times$  15 mm in fruit ..... 5. *T. ambacense*
    - 3b Accrescent calyx lobes  $\pm$  rounded at base:
      - 4a Stems, inflorescence axes and calyx spinously hairy; lower leaf surfaces sparsely hairy with setae scattered along midribs and veins ..... 2. *T. africanum*
      - 4b Stems, inflorescence axes and calyx patently hairy; lower leaf surfaces with setae only along midribs and veins, intercostal surfaces with a dense cover of small, bulbous-based hairs, orientated in different directions ..... 1. *T. zeylanicum*

(1967); Taton: 37 (1971); Kabuye & Agnew: 520 (1974); S.P.Banerjee & Pramanik: 109 (1975); Tölken: 1172 (1986); Brummitt: 95 (1990); Nowicke & J.S.Mill.: 25 (1991); Verdc.: 92 (1991); E.S.Martins & Brummitt: 62 (1993); Retief & P.P.J.Herman: 354 (1997); Riedl: 125 (1997). Type: Ceylon. *Garcin* in *Herb. Burm.* (G, lecto.-K, photo.).

*Borago zeylanica* Burm.f.: 41 (1768). *Pollichia zeylanica* (Burm.f.) F.Muell.: 100 (1882). *Boraginella zeylanica* (Burm.f.) Kuntze: 435 (1891). *Boraginoides zeylanica* (Burm.f.) Hiern: 720 (1898).

*Leiocarya kotschyana* Hochst.: 30 (1844). Types: Ethiopia, Djelajerranne, *Schimper* 625 (B, syn.†, BM, K! isosyn.) & Sudan, Nubia, Camamil and Gebbel Kassan, *Kotschy* 542 (B†, K!, W, isosyn.).

Erect, perennial herb with annual stems from a woody rootstock, up to 1.5 m high. *Stems*, inflorescences and petioles patently hairy. *Leaves* sessile or petiolate; blade elliptic, 30–110(–120)  $\times$  10–30(–35) mm, base rounded to subcordate, apex acute, discolorous, upper surface with long, up to 0.75 mm, larged-based, 2-layered setae and much smaller setae in between, orientated  $\pm$  in same direction, lower surface with long setae on midrib and major veins only, intercostal area densely covered with small, bulbous-based setae orientated in different directions; petiole up to 10 mm long. *Flowers* with pedicels up to 30 mm long in fruit. *Calyx* lobes ovate,  $\pm$  9  $\times$  3 mm in flower, 15–18  $\times$  7–9 mm in fruit. *Corolla* very pale blue,

1. ***Trichodesma zeylanicum*** (Burm.f.) R.Br., *Prodromus florae novae hollandiae*: 496 (1810); A.DC.: 172 (1846); A.Rich.: 91 (1850); Hook.: t. 4820 (1854); Klotzsch: 255 (1861); Gürke: 99 (1897); Baker & C.H.Wright: 51 (1905); Brand: 40 (1921); F.W.Andrews: 90 (1956); Ivens: 83

darker at edges of lobes, with reddish purple marks at junction of lobes or lobes with white along mid-area, blue in outer areas; tube funnel-shaped, 5–7 mm long; lobes 5 or 6, broadly ovate,  $\pm 5 \times 1.5$  mm, with abrupt, acuminate apices, usually twisted. *Fruit* of four nutlets; nutlets greyish marble brown, compressed ovoid,  $\pm 4.0$ –4.5 mm long, external face  $\pm$  convex, shiny, internal face 3-angled, rugose. *Flowering time*: January to December.

Although different infraspecific taxa of *T. zeylanicum* have been described, the species does not warrant subdivision in southern Africa. In Australia the species does show differences and three forms are recognizable (Randall 1993).

**Distinguishing characters:** stems, inflorescence axes and petioles patently hairy; leaves discolorous because upper and lower leaf blade surfaces differ in indumentum; calyx lobes 15–18  $\times$  7–9 mm in fruit; apices of corolla lobes acuminate; nutlets smooth, shiny and grey-marbled. **Distribution:** Namibia (Caprivi), eastern parts of the Northern Province, Mpumalanga, Swaziland and northern KwaZulu-Natal (Figure 8); also known from various regions in eastern Africa, the Comoros, Madagascar, the Mascarenes, India, Sri Lanka, Malaya, Java, the Philippines and Australia (Verdcourt 1991), having reached at least some of these areas presumably as a weed of cultivation. **Habitat:** grassland, woodland, in dry river beds, common weed in old and new cultivated land, pioneer in disturbed areas, along roadsides; well-drained sandy, gravelly turf, poorly drained loam or in rocky well-drained soil; full sun. **Illustrations:** Hooker: t. 4820 (1854); Ivens: 83 (1967); Moriarty: t. 103 (1975); Verdcourt: 93 (1991); Bromilow: 157 (1995).

**2. *Trichodesma africanum* (L.) Lehm.,** *Plantae e familia Asperifoliarum nuciferae*: 195 (1818) non R.Br.; C.H.Wright: 11 (1904); F.W.Andrews: 88 (1956); Riedl: 220 (1967); Friedr.-Holzh.: 3 (1967); H.Heine: 323 (1963); Kazmi: 519 (1971); Qaiser: 31 (1979). Type: 'habitat in Aethiopia', *LINN 188.4* (LINN, syn.-PRE, microfiche!).

*Borago africana* L.: 138 (1753). *Pollichia africana* (L.) Medik.: 247 (1783). *Borriginoides aculeata* (L.) Moench: 515 (1794). *Borriginella africana* (L.) Kuntze: 435 (1891).

*Borago verrucosa* Forssk.: 41 (1775). Type: Egypt, Cairo, *Forsskål* 288 (C, holo.).

*Borriginoides africana* (L.) Hiern: 721 (1898). Type: Angola, Mossamedes, *Welwitsch 5303* (PRE, syn.!).

Erect, annual or biennial herb, up to 1 m high, harshly scabrid. *Stems* branched, covered with stiff, tubercle-based setae; setae up to 2 mm long. *Leaves* opposite, sessile or petiolate; blade ovate to narrowly ovate, rarely oblong, 50–105(–120)  $\times$  5–30(–80) mm, base auriculate, apex acute, upper surface with setae of different sizes; setae on lower surface stiff, with tubercle-like multicellular bases, mainly on veins; petiole up to 40 mm long. *Inflorescences* terminal at ends of stems and also terminal on lateral branches; flowers with pedicels up to 15 mm long in fruit. *Calyx*: lobes narrowly ovate,  $\pm 6 \times 2$  mm in flower,  $\pm 12 \times 6$  mm in fruit, base truncate to subcordate, apex acuminate, midrib and margins densely hairy with long, stiff setae, setae interspersed with small, fine, simple, unbranched hairs. *Corolla* pale pink when

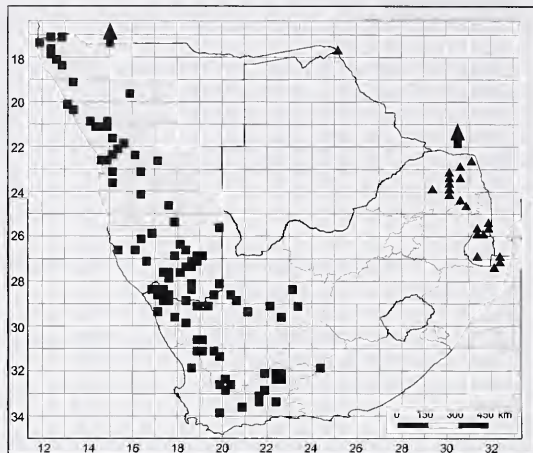


FIGURE 8.—Distribution of *Trichodesma zeylanicum*,  $\blacktriangle$ ; and *T. africanum*,  $\blacksquare$ , in southern Africa.

young, changing to blue, fading white with blue margin, throat yellow with purple spots; tube funnel-shaped, 3–4 mm long; lobes ovate-triangular,  $\pm 2.5$ –3.0 mm long, apices long-acuminate, often twisted. *Fruit* of 4 nutlets; nutlets ovoid-cup-shaped, up to 4 mm long, with glochidia along serrate, raised margins and single ones along midrib, base of cup with thick, short setae and verrucose epidermal protuberances. *Flowering time*: January to December.

*Trichodesma africanum* is a rather plastic species with small leaves and much-branched inflorescences under arid climatic conditions, compared to large leaves and less branched inflorescences when growing in the shade of boulders or during times of above-average rainfall. The different varieties recognized by Brand (1921) and El-Hadidy & Boulos (2000) are not upheld here, but this needs further attention.

**Distinguishing characters:** spinously, patently hairy; leaves variable in size; calyx lobes 12  $\times$  6 mm in fruit; apices of corolla lobes long and acuminate; nutlets ovoid-cup-shaped with distinct serrate, raised margins and a concave, glochidiate inner face. **Distribution:** Namibia, Northern Cape and Western Cape (Figure 8); also known from North and West Africa, Afghanistan, Iran and Pakistan. **Habitat:** disturbed places, road verges, granite or sandstone hills, mountain slopes, among rocks, rocky ridges, dry, sandy river beds, calcareous sandy flats and river banks. **Utilization:** grazed (*Henrici 3393*). **Illustrations:** Heine: 323 (1963); Qaiser: 32 (1979).

**3. *Trichodesma angustifolium* Harv.,** *Thesaurus capensis* 1: 26 (1859); C.H.Wright: 11 (1904); Baker & C.H.Wright: 47 (1905); Brand: 27 (1921); Friedr.-Holzh.: 3 (1967); J.H.Ross: 297 (1972); Brummitt: 852 (1985); Brummitt: 96 (1990); E.S.Martins & Brummitt: 64 (1993); Retief & P.P.J.Herman: 353 (1997); Pooley: 468 (1998). Syntypes: Magaliesberg, *Burke 60, 313* (K, iso.!), *Zeyher 1250* (BM, iso.!), *Zeyher 1251* (K, iso.!), Rhenoster River, Free State, *Sanderson 157* (K, iso.!).

*Boraginella angustifolium* (Harv.) Kuntze: 436 (1891).



Perennial herb or subshrub, up to 1.2 m high, with a woody rootstock, appressed hairy throughout, with setae orientated parallel to midrib of leaves. *Stems* erect or decumbent-ascending; setae variable in size or of  $\pm$  equal length; epidermis often flaking off in older plants. *Leaves* shortly petiolate or blades decurrent; blade linear to narrowly elliptic to linear-elliptic, 20–50  $\times$  (1.5–) 3.0–6.0(–15.0) mm, base narrowly cuneate, apex acute, surfaces with setae dense or with spaces in between; petiole up to 3 mm long. *Inflorescences* terminal at ends of main stems and also terminal on lateral branches, lowermost flowers occasionally solitary in leaf axils. *Calyx* setulose, winged,  $\pm$  11  $\times$  4 mm in flower,  $\pm$  25  $\times$  20 mm in fruit, base cordate, apex long-acute. *Corolla* pinkish in young stage, changing to blue or mauve, fading white; tube cylindric to slightly campanulate,  $\pm$  9–15 mm long; lobes triangular,  $\pm$  5.5  $\times$  4 mm, long-acuminate, often twisted. *Fruit* of 4 nutlets; nutlets glochidiate,  $\pm$  5–6 mm long; glochidia usually coalescing at base to form distinct rim.

**Distinguishing characters:** resprouting perennial, stems, inflorescences and calyces appressed hairy; leaf blades linear to narrowly elliptic; calyx winged,  $\pm$  25  $\times$  20 mm in fruit; nutlets with several-barbed glochidia; glochidia usually coalescing at their bases to form a distinct rim.

#### Key to subspecies

- Indumentum setulose, greyish green; setae well spaced; usually on red, sandy loam; widespread . . . . . subsp. *angustifolium*  
 Indumentum tomentose, silvery grey to greyish green; setae densely packed; usually on lime-rich soils; only known from northern Namibia . . . . . subsp. *argenteum*

#### subsp. *angustifolium*

*Trichodesma lanceolatum* Schinz: 269 (1888). Type: Namibia, Scap River. Schinz 758 (COI!, GRA!, K!, NU!, syn.).

**Flowering time:** October to May. **Distinguishing characters:** indumentum setulose, setae with distinct spaces in between, green; usually on red, sandy loam. **Distribution:** Namibia, Botswana, Northern Province, North-West, Gauteng, Free State, KwaZulu-Natal, Northern Cape (Figure 9); also in Mozambique. **Habitat:** open grassland, open shrubland, mixed shrub savanna, mesophytic closed bush, abandoned lands, disturbed places, mixed ruderal vegetation; red sandy loam, stony soils; plants reach a considerable age and large rootstocks may be more than a century old. **Common name:** blue-bells, according to Smith (1966); 'mothagapele' (Moss BMP735). **Medicinal use:** dried ground root powder mixed with cold water is used for diarrhoea (Moss BMP735). **Illustrations:** Harvey: t. 40 (1859); Pooley: 469 (1998).

subsp. *argenteum* Retief & A.E.van Wyk, subsp. nov., subsp. *angustifolium* affinis sed foliis dense pilosis (non intervallis conspicuis inter bases setarum), plerumque in solo calcareo, non luto arenoso rubro habitat.

**TYPE.**—Namibia, 1916 (Gobaub): Etosha National Park, between Gemsbokvlakte and Olifantsbad, (–AA), Retief 1404.01 (PRE, holo.; WIND).

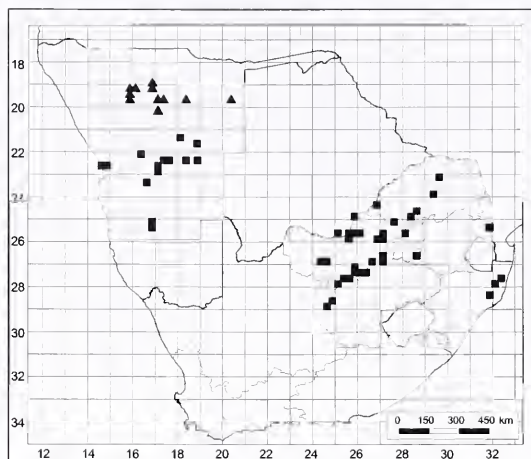


FIGURE 9.—Distribution of *Trichodesma angustifolium* subsp. *angustifolium*, ■, and *T. angustifolium* subsp. *argenteum*, ▲, in southern Africa.

The prominent silver-grey to greyish green indumentum is reflected in the specific epithet: 'argenteum' = silver. The difference in the density of the setae on the leaf surfaces, distinguishes the two subspecies. This distinction is further supported by habitat differences.

**Flowering time:** November to April. **Distinguishing characters:** indumentum tomentose, silvery grey to greyish green; setae densely packed; usually on lime soils. **Distribution:** northern part of Namibia (Figure 9). **Habitat:** grassland, savanna, margins of pans, road verges; usually in grey, lime-rich soils.

**4. *Trichodesma physaloides* (Fenzl) A.DC.,** Prodrum 10: 173 (1846); Gürke: 99 (1897); C.H.Wright: 11 (1904); Baker & C.H.Wright: 46 (1905); Brand: 22 (1921); Pole Evans: t. 351 (1929); Letty: 280 (1962); Taton: 39 (1971); Agnew: 521 (1974); Brummitt: 439 (1982); Brummitt: 96 (1990); Verdc.: 100 (1991); E.S.Martins & Brummitt: 65 (1993); Germish. in A.Fabian & Germish.: 338 (1997). Retief & P.P.J.Herman: 353 (1997); A.E.van Wyk & C.E.Malan: 46 (1997); Pooley: 178 (1998). Type: Sudan, Fazokl, Kotschy 577 (BM, K!, iso.).

*Friedrichsthalia physaloides* Fenzl: 54 (1839). *Boraginella physaloides* (Fenzl) Kuntze: 435 (1891).

*Trichodesma droogmansianum* De Wild. & T.Durand: 69 (1900). *T. droogmansianum* De Wild. & T.Durand var. *glabrescens* (Gürke) Brand: 24 (1921). Type: Zaïre, Lualaba, Descamps s.n. (BR, holo.).

*T. glabrescens* Gürke: 389 (1901). Type: Tanzania, Kinga-Berge, Ussangu, Goetze 1267 (BR, E, iso.–K, photo!).

*T. ringoetii* De Wild.: 100 (1914). Type: Zaïre, Katanga, Nieuw-dorp, Ringoet 6 (BR, holo.).

Perennial herb with 1 to several annual stems from a woody rootstock, up to 0.5 m tall. *Stems*  $\pm$  glabrous, with scattered setae; young stems fleshy, pinkish. *Leaves* sessile, bluish green; blade broadly ovate to narrowly ovate, 30–50(–75)  $\times$  12–16(–32) mm, base cuneate to rounded, apex acute or obtuse, upper surface clothed with short,



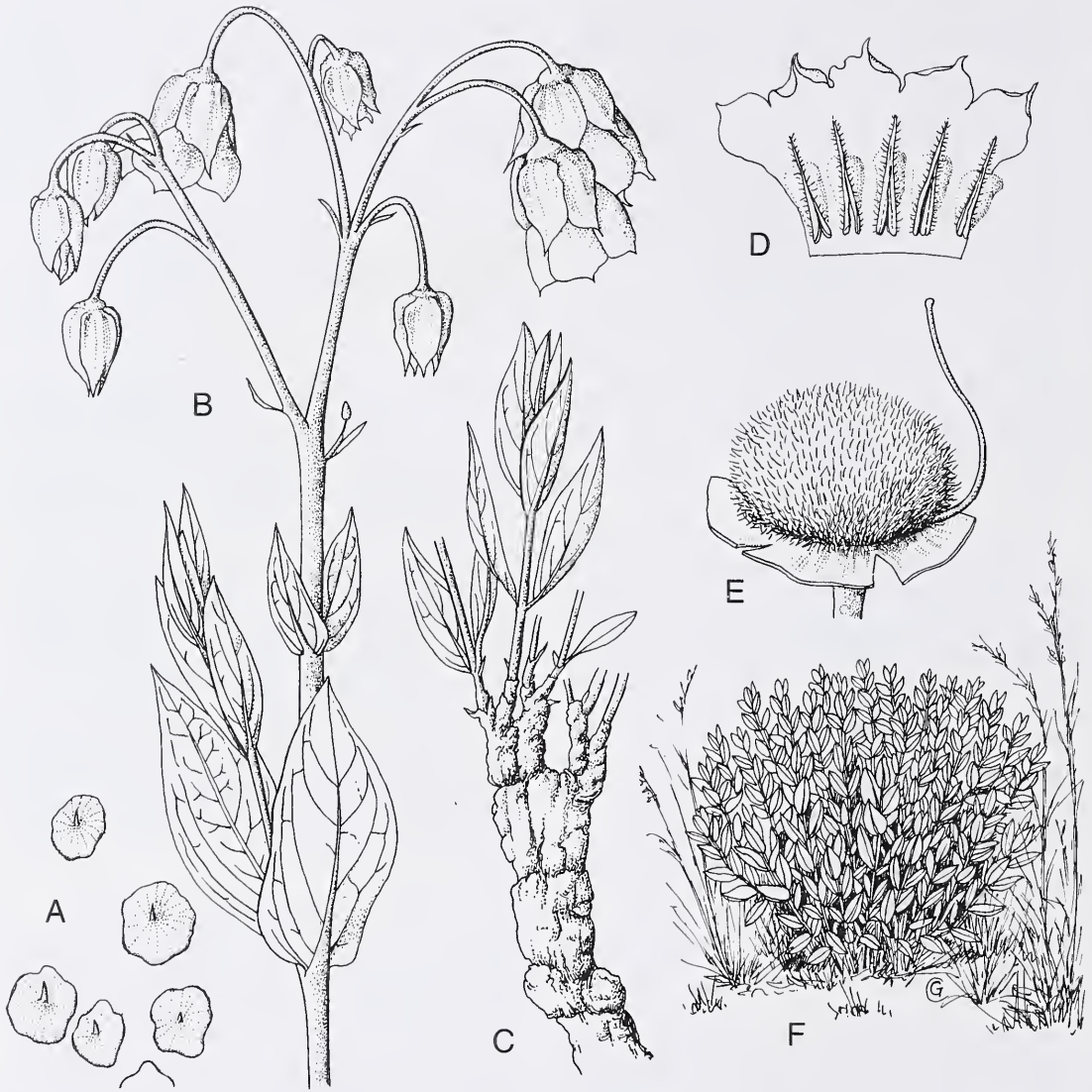


FIGURE 10.—*Trichodesma physaloides*, Germishuizen 2156 (PRE). A, setae on upper surface of leaf,  $\times 23$ ; B, flowering stem,  $\times 1$ ; C, rootstock with young shoots,  $\times 1$ ; D, longitudinal section of corolla,  $\times 1.5$ ; E, nutlet,  $\times 3$ ; F, habit reduced, plant in Pretoria National Botanical Garden. Artist: Gillian Condy.

stiff setae; setae all pointing  $\pm$  in same direction, multicellular base discoid, 3–5-layered; lower surface with scattered setae on midrib and veins only. *Inflorescences* terminal, cymose panicles, cymules scorpioid; pedicels up to 30 mm long, drooping. *Calyx* brownish purple; lobes 13–15  $\times$  5–7 mm in flower, up to 30  $\times$  18 mm in fruit. *Corolla* white with brown gibbosities at sinuses between lobes, apices of lobes with a light brown rim; tube funnel-shaped, hairy inside at level where anthers arise; lobes broadly ovate, apices cuspidate, glabrous or densely pilose down middle of lobes on adaxial side. *Fruit* one discoid nutlet; nutlet with a prominent rim, densely hairy, with style and stigma lateral due to abortion of three other nutlets. *Flowering time*: August to November. Figure 10.

*Distinguishing characters*: multistemmed greyish green suffrutescent; stems glabrous or with setae with promi-

nent discoid, multicellular bases; flowers drooping; calyx brownish purple; corolla white with a light brown rim at apices of lobes; fruit a hairy, discoid nutlet. *Distribution*: Northern Province, North-West, Gauteng, Mpumalanga, Swaziland, KwaZulu-Natal (Figure 11); also known from southern Sudan, western Ethiopia, Kenya, Uganda, Burundi, Tanzania, Zaïre, Zambia, Malawi, Zimbabwe and Mozambique. *Habitat*: grassland, woodland, open mixed bushveld, hill slopes, disturbed areas, roadsides, waste places; sandy loam, clay, loam or rocky soils, gravel; large plants may have rootstocks well over a century old. *Common name*: chocolate bells. *Illustrations*: Pole Evans: t. 351 (1929); Letty: t. 139, 3 (1962); Moriarty: t. 30 (1975); Brummitt: 431 (1982); Onderstall: 167 (1984); Brummitt: 97 (1990); Fabian & Germishuizen: 339 (1997); Van Wyk & Malan: 47 (1997); Pooley: 179 (1998).

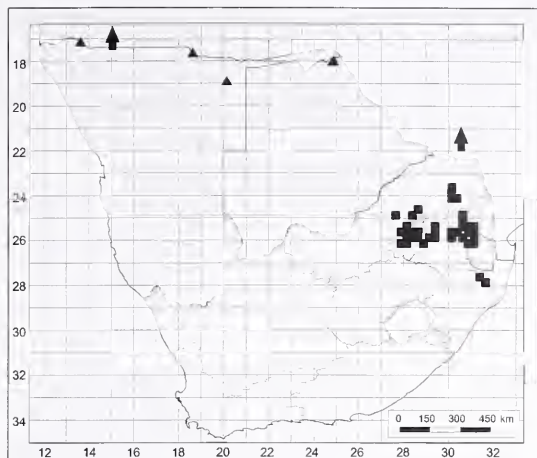


FIGURE 11.—Distribution of *Trichodesma physaloides*, ■; and *T. ambacense* subsp. *hockii*, ▲, in southern Africa.

5. *Trichodesma ambacense* Welw. in Annaes do Conselho ultramarino 1: 589 (1859) as '*ambacensis*'; Brummitt: 442 (1982); Brummitt: 98 (1990); Verdc.: 101 (1991). *Boraginella ambacensis* (Welw.) Kuntze: 435 (1891). *T. angolense* Brand: 26 (1921), nom. superfl. illegit. Type: as for *T. ambacense* above. Type: Angola, Welwitsch 5450 (LISC, holo.; BM, BR, COL!, K!).

Currently *T. ambacense* is divided into two subspecies (Brummitt 1982). *T. ambacense* subsp. *ambacense* is endemic to Angola. It differs from subsp. *hockii* in the leaves which are obovate to oblanceolate (not ovate to elliptic) and calyx lobes which are 3–5 mm long in flower (not 5–8(–9) mm long).

subsp. *hockii* (De Wild.) Brummitt in Kew Bulletin 37: 443 (1982); Roessler: 39 (1984); Brummitt: 98 (1990); Verdc.: 101 (1991); E.S.Martins & Brummitt: 67 (1993); E.S.Martins: 5 (1993); Bolnick: 32 (1995). Type: Zaïre, Shaba, Lubumbashi [Elisabethville], Hock (BR, holo., –K, photo.!).

*Trichodesma hockii* De Wild.: 546 (1913).

*T. ledermannii* Vaupel: 529 (1912). Type: Cameroon, near Laro, Ledermann 3080 (B, holo., †).

*T. tinctorium* Brand: 393 (1914). Type: Zaïre, Shaba, Lukafu, Verdict 104 (BR, holo.).

*T. verdickii* Brand: 329 (1914). Type: Zaïre, Shaba, Lukafu, Verdict 140 (BR, holo.).

Perennial herb with annual stems from a woody rootstock, up to 0.5 m high. Stems hairy or setose. Leaves sessile or occasionally shortly petiolate; blade ovate to elliptic, 50–65 × 20–27 mm, base cuneate, apex acute; petiole up to 1.5 mm long. Inflorescences terminal at ends of stems, cymose panicles, cymules scorpioid; flowers slightly pendent; pedicels up to 25 mm long in fruit. Calyx ± 14 × 8 in flower, ± 22 × 15 mm in fruit. Corolla deep blue, pale lavender to white with raised amber-brown gibbosities at sinuses of petal lobes; tube campanulate, lobes reflexed, apices acuminate. Fruit:

one, densely silken-haired nutlet; hairs usually hooked. Flowering time: June to September.

*Distinguishing characters*: multistemmed suffrutex; stems hairy; leaf blade elliptic; setae with prominent discoid, multicellular bases, usually hooked at apices; flowers slightly pendent; corolla deep blue, lobes reflexed; fruit a silken-haired nutlet. *Distribution*: Namibia, Botswana (Figure 11); also known from Sudan, Nigeria, Cameroon, Uganda, Kenya, Tanzania, Zambia, Malawi, Mozambique and Zimbabwe. *Habitat*: grassland, woodland, abandoned fields, roadsides; sandy soil. *Common name*: bells of St Mary's. *Illustrations*: Moriarty: t. 103 (1975); Martins & Brummitt: 69 (1993); Bolnick: t. 15 (1995).

SPECIMENS EXAMINED (southern Africa only)

Numbers in brackets signify the identity of the specimens: (1) *Trichodesma zeylanicum*; (2) *T. africanum*; (3a) *T. angustifolium* subsp. *angustifolium*; (3b) *T. angustifolium* subsp. *argenteum*; (4) *T. physaloides*; (5) *T. ambacense* subsp. *hockii*.

Acocks 1541 (3a) PRE; 1619, 18133 (3a) K, PRE; 2026, 2533 (2) BOL, K, PRE; 2578 (3a) BOL, PRE; 2587 (3a) K. Acocks & Hafström 1314, 1350 (2) PRE; 1315 (4) PRE. Adamson D147 (2) PRE. Anderson N18 (3a) PRE.

Balkwill 1499 (1) NU, PRE. Balkwill & Cadman 3501 (4) E, PRE. Balsinhas 3014 (3a) K, PRE. Balsinhas & Kersberg 2006 (2) PRE. WIND. Barber s.n. (3a) K; PRE13748 (3a) PRE. Barker 102 (4) J; 791 (3a) PRE. Barnard SAM36092 (2) SAM. Barrett 132 (1) K, PRE. Bengis 463 (2). Bolus 641 (2) BM, BOL, K; 5713 (3a) K; 6443 (3a) BOL, PRE; 9706 (4) BOL; 10399 (2) BOL. Bond 842 (2) NBG. Boshoff & Mason 2541 (3a) PRE. Boss 18, A80, TRV35550 (3a) PRE; TRV36168 (2) PRE. Botha & Ubbink 1733 (3a) PRE. Boucher 5147 (2) NBG. Bradfield 583 (2) K, PRE. Brenekamp TRV27519 (1) PRE. Breyer PRE59361, TRV17580 (1) PRE; PRE59405, TRV20582 (3b) PRE. Brown & Kolberg 277 (3b) WIND. Bryant J118 (2) PRE; 894B (2) K. Buchanan snb Wood 7032 (4) PRE. Buitendag 626 (4) K, PRE. Burchell 1264 (2) K, PRE. Burger & Lonw 297 (2) NBG, PRE. Burgoyne 408 (4) PRU. Burke 60, 313 (3a) K; PRE13749 (4) PRE. Burr Davy 2051 (4) PRE; 7048 (3a) K; 11009, 11278, 14393 (3a) NBG.

Catell 314 (2) NBG. Chemells 151 (3a) BOL, PRE. Clarke 22/57 (1) PRE; 1318 (4) PRE. Codd 627 (4) PRE; 2084, 6645 (3a) K, PRE. Cole 1388 (3a) PRE. Collins 663 (2) K, PRE; 1801 (2) PRE. Compton 2447, 11530, 20616 (2) NBG; 27100 (4) K, PRE; 28934 (1) NBG, PRE. Craven 14, 184, 216, 1556, 1939, 3136 (2) WIND. Crook M37, 737 (4) PRE. Crosby 863 (2) PRE. Cross 228 (4) PRE.

Davidse 6285 (2) PRE. Davies, Thompson & Miller 48, 104 (2) PRE. WIND. De Kruij 1231 (4) PRE. De Lange UNIN6718 (4) PRE, UNIN. De Sousa 559 (4) PRE. De Winter 419 (5) BM, K, PRE; 2473 (3a) K, PRE. WIND. De Winter & Giess 6158 (2) K, PRE. WIND. De Winter & Leistner 5685 (2) K, PRE. WIND. Dean 325 (2) BOL, PRE. Dinter 415 (3a) K, SAM; 925 (3b) NBG; 1213, 1273 (2) SAM; 3503 (3a) K, PRE; 4296 (3a) BM, SAM; 4799 (2) K; 8423 (3a) BM, K. Dlamini PRE40761 (4) PRE. Drège s.n. (2) K. Drèyer 52 (2) PRE. Du Plessis 814, 1046 (4) PRE, PRU; 3100 (4) K, PRE.

Edwards PRE40742 (4) PRE. Elan-Pittick 292 (4) PRE. Esterhuysen 2712 (2) NBG, PRE; 4488 (2) BOL. Evrard 9034, 9243 (2) PRE.

Fourie 2804 (4) PRE. Francois 45 (4) E. Fries, Norlindh & Weinarc 1966 (4) PRE. Fuller PRE10596 (4) BM.

Galpin 502M, 503M (3a) PRE; 504M, 6994 (4) PRE; 9223 (1) PRE; 9288 (4) K, PRE; 11380 (1) K, PRE; 13700 (3a) K, PRE; 14111 (2) BOL, K, PRE; 15097 (5) E. Galpin s.n. (4) K. Galpin & Pearson 1561 (2) BOL; 7506 (2) K, PRE. SAM. Gernishwizer 2156 (4) K, PRE; 3086 (4) PRE; 4575, 5377, 5431 (2) PRE. Esterhuysen 3435 (4) NH; 4101 (3a) NH; 5119 (4) K, PRE; 5133 (3a) PRE; 6616 (1) PRE. Gibbs



Russell, Robinson & Herman 311 (2) PRE. Giess 3628 (2) WIND, 8033 (2) PRE, WIND; 8311 (3a) PRE, WIND; 9488 (5) WIND; 10700 (3a) WIND; 1331 (5) PRE, WIND. Giess & Loutit 14101 (3b) K, PRE, WIND. Giess & Müller 11980 (2) K, PRE, WIND. Giess & Van Vuuren 947 (3a) K, PRE, WIND. Giess & Wiss 3295 (2) WIND. Giess, Volk & Bleissner 6276 (2) WIND; 6512 (3b) WIND. Gillet 2599 (3a) K; 4625 (4) K. Goldblatt 1986 (2) PRE, WIND; 2349A (2) NBG, PRE; 7003 (2) PRE. Goossens PRE40757 (4) PRE. Greenway 8113 (4) PRE. Greuter 21604, 21802 (2) PRE. Gubb 32.92 (3a) PRU.

Hall 57, 74 (1) NBG; 400, 798 (2) NBG. Harris 127 (4) PRU. Hanekom 1498 (3a) K, PRE; 1619 (3a) K; 2151 (2) K, PRE. Hansen 3277 (3a) PRE. Hardy 1950 (2) K, WIND; 2470 (2) K, PRE; 5656 (1) K, PRE. Hardy & Bayliss 1239 (3a) K, PRE. Hardy & De Winter 1393 (2) PRE. Hardy & Venter 4565 (2) K, PRE, WIND. Henrici 74 (3a) PRE; 3393 (2) PRE. Heymans 13 (4) J. Hill PRE40760 (3a) PRE. Hilliard 4731 (1) NU. Hillary & Robertson 601 (3a) PRE. Hines 400 (3b) WIND. Hutchins 319 (1) PRE. Hoffmann 1233 (2) NBG. Holt 8 (4) NH. PRE. Homann, Benseler & Mittendorf 22 (2) WIND. Howlett PRE40752 (4) PRE. Hugo 505, 2533 (3) K, NBG, PRE. Hutchinson 2987 (3a) BM, BOL, K, PRE. Hutchinson & Gillett 3590 (5) COI.

Ihlenfeldt, De Winter & Hardy 3226 (2) PRE. Immelman 569 (3a) PRE, WIND; 579 (2) PRE.

N. Jacobsen 1813 (4) PRE. W.J. Jacobsen 1059 (3a) PRE. JBG6154 (4) PRE. Jeffers 414 (3a) PRE. Jenkins 7432, 9130, TRV9130 (4) PRE; 7538 (3a) PRE; TRV8185 (1) PRE. Jensen 49, 70, 195, 241, 281, 1395 (2) WIND. Joffe 332 (4) PRE. Joubert 100/1447 (3b) WIND. Junod 548 (1) K, PRE; 604 (4) K; 5022 (1) E; 604 (4) K, PRE.

Karsten PRE31340, PRE31341 (4) PRE. Kers 7062, WIND26641 (2) WIND. Killian 20 (1) K, PRE. Kinges 1851 (4) PRE; 2305, 2399 (2) PRE, WIND. Kluge 113 (4) K, PRE, PRU. Koch A15 (2) PRE. Kok 265 PRE, PRU; 1046 (4) PRU. Kraeusel & Wiss 1913 (2) WIND. Krynauw 70 (3a) PRE; 1283 (4) PRE. Kubirske 186 (2) K. Kubirske, Strohbach & Swart 186 (2) WIND.

La Croix 3339, 4874 (4) PRE. Laidler 662 (2) NBG, PRE. Lang TRV32136 (1) PRE. Lavanros 11019 (2) PRE. Lavanros & Phelemann 20148 (3a) WIND. Lea 43 (4) PRE. Leendert 267, 360, 824 (4) PRE. Le Roux 13 (4) PRE, 483 (3b) PRE, WIND; 3064 (2) NBG. Leach & Bayliss 13067 (2) K, PRE, WIND. Leeman PRE40744 (4) PRE. Leendert 267, 300, 824, 7594 (4) PRE; 713A, 8519, TRV11437 (3a) PRE. Leistner 1240 (3a) K, PRE; 2338 (2) K, PRE. Leistner & Joyn 2846 (2) PRE. Leistner, Oliver, Steenkamp & Vorster 139 (2) K, PRE. Leuenberger, Raus & Schiers 3266 (2) WIND. Levyns 1742 (2) BOL. Liebenberg 5008 (2) PRE, WIND; 5103 (3a) WIND; 5158 (2) K, PRE, WIND; 5703 (3a) PRE. Lloyd 35, 36 (2) PRE. Louw 2029 (3a) PRE.

MacCallum 541, 1589 (4) PRE. MacDonald 97, 357, 490, 568 (2) BM; 383 (3a) BM. Maguire 365 (2) NBG. Magun 9 (1) PRE. Mathibe 64 (4) PRU. Matthews 230 (2) PRU. Methuen 166 (4) PRE. Miller 2489 (4) PRE. Marloth 780 (3a) PRE; 1188 (2) NBG; 1411, 2034 (2) PRE; 10162 (4) PRE; 12380 (2) NBG, PRE. McMurry 4100, 10773, 15325, 19179, 23918 (4) J. Meebold SAM51370 (1) SAM. Merxmüller 739, 1669 (2) PRE, WIND; 1325 (3b) K, PRE. Merxmüller & Giess 1325 (3b) WIND; 1669 (2) WIND; 2827, 28107 (2) PRE, WIND. Mogg 8176 (3a) PRE, SAM; 8363, PRE11704, SAM44701 (3a) PRE; 9450 (4) SAM; 15325, PRE9449, PRE10773 (4) PRE; 19179, 23918 (4) J. Moore 44 (3a) PRE. Moran PRE40756 (3a) PRE. Morris & Engelbrecht 1135, 1155 (3a) K, PRE. Moss BMP735 (3a) PRE; 4736, 22227 (4) J; 8855 (4) BM. J. Moss & Jacobsen K218 (2) PRE. Müller 29 (3a) PRU, WIND; 124 (2) PRE, WIND; 781 (3a) PRE; 1290 (3a) PRE, WIND. Müller & Loutit 1198 (2) WIND. Murray 614 (3a) PRE; 641 (4) PRE. Myre 21 (1) PRE.

Nation 288 (3a) K. Nelson 236 (3a) PRE. Netshiungani 915 (1) PRE. Nicholas 2576 (2) PRE, WIND.

Obermeyer 711 (1) PRE; NH27321 (4) NH; TRV34735 (4) BM, PRE. Oliver & Steenkamp 6291 (2) K, PRE, WIND. Oliver, Tölken & Venter 89 (2) K, NBG, PRE. Onderstall 443, 1248 (4) PRE.

Pager P35 (2) WIND. Papendorf 375 (1) PRE. Parry PRE8016 (1) PRE. Patterson 21 (1) PRE. Pearson 3665 (3a) BOL, K, PRE, SAM; 3674 (3a) K, PRE; 4961 (2) K, NBG, PRE; 4993, 6005 (2) K; 6106 (2) BM, K; 8551, 9123 (2) BOL, K; 9110, 9531 (3a) BOL, K. Peeters, Gericke & Burelli 163 (3a) PRE. Pegler 979 (3a) BOL, K, PRE, SAM.

Peyper 1333 (3a) PRE. E. Phillips 1117 (4) J; 3275 (4) J, PRE. J. Phillips 1616 (4) PRE. Phillips & Liebenberg 916 (3a) PRE. Phipps 778 (4) PRE. Pienaar 1089 (2) BOL, PRE. Pienaar & Vahrmeijer 478 (1) PRE. Pillans 5074 (2) BOL, K; 5856 (2) BOL. Plowes 7046 (3a) PRE. Pole-Evans 2827 (5) PRE; s.n. (4) K; PRE40746 (4) PRE; PRE12870, PRE13241, PRE40765 (3a) PRE. Pont 512 (3a) PRE. Potts BLFU2676 (3a) BLFU. Pooley 435 (3a) NU; 524 (1) NU. Prosser 11071 (4) K, PRE; J029438 (4) J; JBG1204 (4) PRE.

Range 1030 (3a) SAM. Rehmann 4522 (3a) BM, BOL; 4759 (4) BM, BOL. Repton 283 (4) PRE; 3410 (3a) K, PRE; UNIN4540 (4) PRE. Retief 1404.01 (3b) PRE, WIND; 2223, 2224 (4) PRE. Roberts PRE15862 (4) PRE. Rodin 2862 (3a) BOL, K; 3657 (3a) BOL, K, PRE. Rogers 5039, 22270 (3a) PRE; 8290 (4) BOL; 13453 (1) PRE; 15322 (2) K; 18123 (1) K; 21405 (4) SAM; 22072, TRV26665 (4) PRE. Rösch & Le Roux 109, 179 (2) PRU, WIND. Rusch 45 (2) WIND.

SAGP/SAAB 176 (4) K, PRE, PRU. Sanderson 157 (3a) K. Scheepers 349 (1) K, PRE, PRU, UNIN; 1166 (4) BM, K, PRE, PRU; 1616 (3a) PRE. Schienck 49 (3a) PRE. Schinz 758 (3a) COI. GRA, K, NU. Schlechter 3601 (4) BM, E, J, PRE; 3677 (3a) BM, BOL, K, PRE; 5365 (3a) PRE; 10871 (2) BM, BOL, COI, K, PRE. Schlieben 8996 (2) BM, K, PRE. Schmidt 295 (2) PRE, WIND. Schoenfelder 227 (3a) PRE. Schulze 8 (1) PRU. Schweickerdt 1102 (3a) PRE. Schwerdtfeger 4181 (3a) WIND; 4286 (2) WIND. Seely 2009 (2) WIND. Seely & Robinson 306 (2) WIND. Seely & Ward 8, 9 (2) WIND. Seydel 314 (2) K; 1845 (3a) WIND; 1847, 2074 (3a) K; 2076 (3b) WIND; 1049, 2470, 4049 (3a) K, PRE, WIND; 2971, 4334 (2) K. Shearing 115, 620, 1083 (2) PRE. Sim 20638 (1) PRE. Smit 1759 (4) PRU. Smith 153, 875, 1082A, 1215, 2131, 3250 (3a) PRE; 821, 837 (4) PRE. Smook 7695, 8691 (2) PRE. Smook & Harding 713 (2) K, PRE. Smuts & Gillett 3290 (4) PRE. Snyman C (1) PRE. Stalmans 158, 1408 (4) PRE; 1076 (1) PRE; 1996 (1) J. Steiner 624 (2) NBG. Stewart TRV8883 (4) PRE; 8966 (3a) PRE; 8970 (1) PRE. Stohr 219 (4) BOL. Story 758 (3a) PRE; 1361 (4) PRE; 5745 (2) K, PRE. Strey 2020 (2) BOL, PRE; 2153 (3a) K, PRE; 6588 (1) K, NU, PRE; 7890 (1) PRE. Strohbach 29 (2) WIND. Sutton 228 (3a) PRE.

Taylor 3396 (1) NBG; 3462B, 11537 (2) NBG. Theiler PRE59972 (3a) PRE. Theron 1517 (4) PRE, PRU; 3899 (2) PRU. Thode 4764, 4766 (3a) PRE; A1453 (3a) K, PRE. Thorncroft TRV4550 (4) PRE; NH11609 (4) NH. Thorne SAM51582 (2) SAM. Tinley 1108 (3b) PRE, WIND. Tölken & Hardy 717 (3a) K, PRE, WIND. Trapnell 507 (4) K. Tuck 813 (3a) BOL, SAM; 2213 (3a) BM.

Ubbink 744, 1141 (3a) PRE. Ueckermann 7295 (2) PRE.

Van Breda 4009, 4331, 4416 (2) PRE. Van Dam PRE59662, TRV25002 (1) PRE. Van der Schijff 542 (1) KNP, PRE; 3132 (1) K, KNP, PRE; 5952 (1) PRU; 8195 (2) PRE, PRU. Van Hoepen 1952 (2) BOL. Van Jaarsveld 1496, 2529, 8413, 11921 (2) NBG; 8825 (2) NBG, PRE. Van Rooyen 2017 (4) K, PRE, PRU; 2268 (2) PRU. Van Wyk 707 (2) PRE; 734 (3a) PRE; 1748 (4) PRE; 3803 (1) PRE, PRU; 6582 (2) PRE, PRU; 8578A (2) PRE, PRU, WIND; 8595 (2) PRE, PRU; 8778 (2) PRE, PRU, WIND; 12682 (1) PRU. Vinjevold CV11 (2) WIND. Visser 210 (2) PRE, PRU. Vlok 1491 (2) PRE. Volk 867 (3a) PRE; 2465A (2) PRE. Von Koenen 559, WIND26672 (3a) WIND.

Wallich 1847, s.n. (4) K. Walter 981 (3b) WIND. Wanntrop 676 (3a) PRE; 979 (2) K, PRE. Ward 2596 (1) PRE; 3216 (3a) K, NU, PRE; 12614 (1) NU. Wasserfall 1098 (2) K, PRE. Watnough 866 (2) PRE. Way PRE31343 (4) PRE. Wells 2217 (3a) K, PRE. Wendt 25/4, 32, 85, 2616, C/20, sub Giess 13614, sub Giess 14762 (2) WIND. Werdermann & Oberdieck 587 (2) PRE; 2331 (3b) K, NBG, PRE. Wild 3331 (1) PRE. Williams 169 (4) E. Williamson 3958, 5562 (2) NBG. Wilman PRE40755 (3a) PRE. Wilms 943 (3a) BM, K, Wiss 1944 (2) WIND. Wood 7002 (4) PRE. Worsdell s.n. (3a) K.

Young A190 (4) PRE.

Zeyher 98 (4) SAM; 1239 (2) BM, K, SAM; 1249 (4) K, PRE, SAM; 1250 (3a) BM; 1251 (3a) BM, K, SAM. Zietsman 1747 (2) WIND; 2100 (2) PRU. Zinn SAM63451 (2) SAM.

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## Six new species and one new subspecies of *Erica* (Ericaceae) from Western Cape, South Africa

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**Keywords:** *Erica* L., new species, South Africa, taxonomy, Western Cape

### ABSTRACT

Two new species and one new subspecies belonging in §*Ceramia* of the genus *Erica* L. are described from the western half of the province—*E. cavartica* known from a single collection growing in a cave in the Cederberg, *E. amalophylla* confined to a shaded rocky overhang and known only from a single collection in the Porterville Mountains and *E. cymosa* subsp. *grandiflora* occurring in the mountains between Ceres and Worcester. Four new species are described from mountains in the Little Karoo area—*E. schelpeorum* occurring widespread mostly in dry watercourses in arid vegetation at low altitudes, *E. lithophila* found only in dry rock crevices at high altitude in the eastern Swartberg and Kammanassie Mountains, *E. umbratica* confined to shaded rocky habitats and known only from a few, very localized small populations at low altitude in Meiringspoort, and *E. annalis* restricted to the arid habitats on lower northern slopes of Kammanassie Mountains. Each is provided with a detailed drawing and a distribution map.

### SPECIES IN §*CERAMIA*

In §*Ceramia* of the genus *Erica* L. there are many species which are associated with damp, shaded or wet habitats. Most are soft, low shrublets, either erect and compact or diffuse and sprawling, with long delicate main branches and often with open-backed leaves. The section contains a group of species (the *E. planifolia* group) which are closely related due to the position of the bract being on the main stem and leaf-like and not recalcrescent on the pedicel (bract = leaf, in our terminology), and to a thickened midrib which is distinctly enlarged towards the distal end of the lamina and/or beyond the lamina apex. Within this group there were collections of herbarium material made by Thomas Stokoe and Elsie Esterhuysen that had not been placed with any certainty within a species and remained unnamed.

The three new taxa have a very similar facies with similar stems, leaves and bract but with differences noted in the corolla size, the presence of anther appendages, the ovary indumentum and the filament shape. They all occur in shaded, damp habitats.

1. *Erica cavartica* E.G.H.Oliv. & I.M.Oliv., sp. nov., bractea non recalcrescenti, bracteolis basalibus, corolla  $\pm 9 \times 4$  mm, filamentis angustis rectis obspathulatis, antheris appendiculatis, ovario glabro, fructu irregulariter rugoso dignoscenda. Figura 1.

TYPE.—Western Cape, 3219 (Wuppertal); Clanwilliam Dist., Cederberg, near Crystal Pool, 4000 ft [1 220 m] (–AC), March 1932, *Stokoe 2600* (BOL, holo.); *ibid.*, as *Stokoe SAM50109* (SAM).

Shrublets soft, sparse, procumbent, single-stemmed reseeders. *Branches*: few old main branches spreading

up to 0.75 m long; numerous secondary branches 50–100 mm long, some bearing flowers; stems with mixture of fine, short, simple hairs and slightly longer, gland-tipped hairs, internodes 10–20 mm long on main branches, 3–10 mm long on secondary branches. *Leaves* 3-nate, spreading, broadly oblong,  $4.0\text{--}6.5 \times 15$  mm, completely open-backed, flattened very thin, both surfaces and margins with sparse, delicate, gland-tipped hairs with fewer on abaxial surface and with a few, shorter, simple hairs admixed, midrib becoming thickened towards apex and beyond apex forming an apical, non-sticky, gland-tipped seta,  $\pm 0.7$  mm long; petiole  $\pm 0.7$  mm long with sparse gland-tipped hairs. *Inflorescence*: flowers 3-nate in 1–3 whorls raceme-like on main and secondary branches, subapical to far removed from apex, continuing growth apically; pedicel 10–20 mm long, covered with long and short gland-tipped hairs and short, simple hairs; bract not recalcrescent, identical to a leaf on stem; bracteoles 2, near base of pedicel,  $\pm 4.0 \times 1.1$  mm, otherwise like bract or leaf. *Calyx* 4-partite, oblong-ovate,  $\pm 3.5 \times 1.5$  mm, green and leaf-like, indumentum as in bract and leaf. *Corolla* 4-lobed, shortly and broadly tubular,  $\pm 9.0 \times 4.5$  mm, sparsely and finely hairy with simple hairs, colour?; lobes erect,  $\pm 1 \times 2$  mm, subacute, margins entire. *Stamens* 8, free, just included; filaments elongate narrow-linear with broad,  $\pm$  elliptic base, glabrous; anthers dorsally attached near base, oblong,  $\pm 1.2 \times 0.5$  mm in adaxial view, bilobed, mucicous; thecae erect adpressed, elliptic-oblong,  $\pm 1.2 \times 0.4$  mm in lateral view, smooth, brown, pore  $\pm \frac{1}{2}$  length of theca; pollen shed in tetrads. *Ovary* 4-locular, 8-lobed, oblate-globose,  $\pm 1.2 \times 1.4$  mm, emarginate, with distinct basal nectaries, glabrous; ovules  $\pm 90$  per locule, spreading from placenta the full length of columella; style exserted,  $\pm 9.5$  mm long, glabrous; stigma simple truncate. *Fruit* a dehiscent capsule,  $\pm 2.2 \times 3$  mm, valves splitting  $\pm \frac{1}{2}$  way down and opening  $30^\circ\text{--}40^\circ$ , with large, irregular wrinkles/folds, not hard and woody, septa mostly on valves. *Seeds* ellipsoid,  $\pm 0.4 \times 0.3$  mm, shiny,  $\pm$  smooth, orange, testa cells elongate,  $\pm 75\text{--}125 \times 25$   $\mu\text{m}$ , anticlinal walls thin jigsawed, inner periclinal walls with numerous small pits. *Flowering time*: March. Figure 1.

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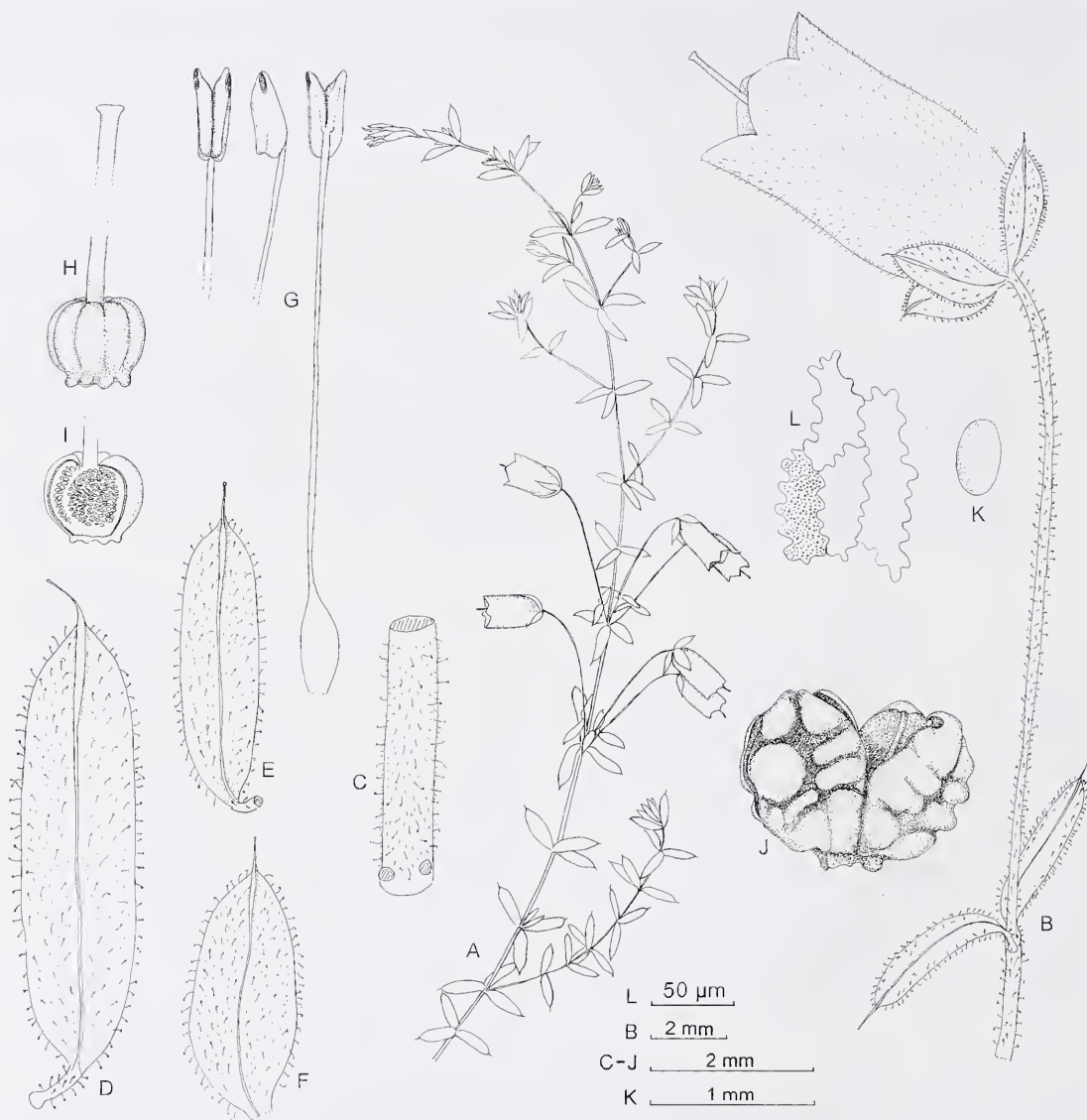


FIGURE 1.—*Erica cavartica*. A, flowering branch, natural size; B, flower; C, stem; D, leaf; E, bract; F, sepal; G, stamen, full in abaxial view, anther in adaxial and lateral views; H, gynoeceum; I, ovary opened laterally; J, capsule; K, seed; L, testa cells. All drawn from the type, Stokoe 2600. Scale bars: B–J, 2 mm; K, 1 mm; L, 50 µm.

**Diagnostic features:** braeteoles basal, leaf-like; corolla long,  $\pm 9 \times 4.5$  mm; filaments narrow straight with spoon-shaped base; anthers muticous; ovary glabrous; fruit with large, irregular wrinkles/folds.

The species is closest to the similar looking *E. cyuosa* E.Mey. ex Benth. For differences between this and the other species in this group see Table 1.

*Erica cavartica* is known only from the type collection made by Thomas Stokoe in the Cederberg (Figure 2). He gave the habitat details to Neville Pillans in the Bolus Herbarium as 'in roek-crevices and on floor of a cave near Crystal Pool'. The name is derived from this habitat preference—*cavarticus* = born or living in eaves

(Latin). Pillans noted at the time that the main branches were up to  $2\frac{1}{2}$  ft [0.75 m] long and proeumbent on large plants but on small plants were erect.

**2. *Erica amalophylla* E.G.H.Oliv. & I.M.Oliv., sp. nov.**, braetecae non recalculescenti, bractaeolis basalibus, corolla  $\pm 3.5 \times 3.5$  mm, filamentis rectis vel ad apicem sigmoideis, antheris appendiculatis, ovario lanato, valvis fructus laevibus dignoscenda. Figura 3.

**TYPE.**—Western Cape, 3319 (Worcester); Piketberg Div., rocky plateau on Twenty Four Rivers Mts above Porterville, (–AA), 16 Dec. 1949, *Esterhuysen 16612* (BOL, holo.; BM, K, NBG, NY, PRE).



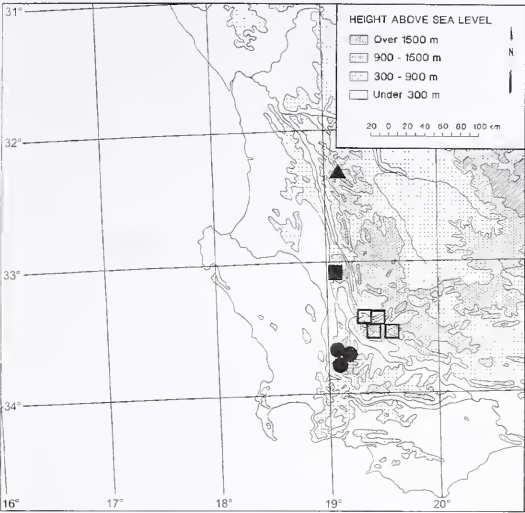


FIGURE 2.—Known distribution of *Erica cavartica*, ▲, *E. amalophylla*, ■; *E. cymosa* subsp. *cymosa*, ●; and *E. cymosa* subsp. *grandiflora*, □.

Shrublets soft, semi-erect to procumbent, 70–12 × 6–36 mm, single-stemmed reseeders. *Branches*: few main branches 100–300 mm long, thin, weak, secondary branches few, ± 20–50 mm long; stems with scattered, long, simple hairs and longer, gland-tipped hairs, internodes (2–)5–10 mm long. *Leaves* 3-nate, spreading, elliptic, 4.5–7.0 × 2 mm, acute, flat and very thin, almost completely open-backed, margins slightly recurved, midrib thickening towards apex and tapering into external simple or sometimes gland-tipped seta, sparsely covered on both sides with long, thin, simple hairs and longer, gland-tipped hairs, margins with a few of same hairs; petiole ± 0.3 mm long, glabrous. *Inflorescence*: flowers 3-nate in 1–3 whorls, raceme-like towards apex of main and secondary branches; pedicel 6–15 mm long, with a few scattered, long, gland-tipped hairs; bract not recaulescent, identical to a leaf on stem; bracteoles 2, near base of pedicel, ± 3 × 0.9 mm, otherwise like a leaf. *Calyx* 4-partite; segments adpressed to corolla, ovate-elliptic, ± 2.5 × 1 mm, otherwise like a leaf. *Corolla* 4-lobed, cyathiform, ± 3.5 × 3.5 mm, thinly textured, white, sparsely hairy with thin, long hairs; lobes erect, broadly rounded, deltoid, ± 0.8 × 1.8 mm, entire. *Stamens* 8, free, included; filaments linear-oblong with slightly broader elliptic base, straight or with

slight sigmoid bend below anther, glabrous; anthers bilobed, erect, dorsally attached ± 1/3 up the back, muticous; thecae adpressed with slightly spreading apical portion, yellow, smooth, pore ± 1/4–1/3 of theca; pollen shed in tetrads. *Ovary* 4-locular, broadly ovoid to broadly ellipsoid, ± 0.8 × 1 mm, emarginate, covered with numerous long, erect hairs, with nectaries around base; ovules ± 15 per locule, suberect from placenta the full length of columella; style included or just beyond corolla mouth, ± 2 mm long, glabrous; stigma subsimple truncate. *Fruit* a dehiscent capsule, valves splitting to base and opening up to 45°, smooth, septa only on valve. *Seeds* ellipsoid, ± 0.4 × 0.2 mm, smooth, orange; testa cells elongate, 60–100 × 20–22 µm, inner anticlinal walls thin, evenly broadly jigsawed, inner periclinal walls with medium-sized pits. *Flowering time*: December. Figure 3.

*Diagnostic features*: bracteoles basal, leaf-like; corolla short (± 3.5 × 3.5 mm); filaments broadish, straight or with slight S bend subapically, with slight spoon-like base; anthers muticous; ovary woolly; fruit smooth, not wrinkled.

The plants within this alliance of three species are all rather soft and delicate with the leaves thin, flat and open-backed. The name of the species is derived from this feature—*amalophylla* from *amalos* = soft, tender, weak; *phyllon* = leaf (Greek). For species alliances and differences see Table 1.

*Erica amalophylla* is known only from the type collection made by Elsie Esterhuysen in the mountains southeast of Porterville which drain into the Twenty Four Rivers system (Figure 2). She noted that the plants were 'growing on shaded sandy floor of overhanging rock shelter'—a similar habitat description to that of *E. cavartica*.

3. *Erica cymosa* E.Mey. ex Benth. in DC., Prodrromus 7: 670 (1839). Type: ad Dutoitskloof prov. Worcester, *Drège 1185* (K!, lecto.; BM!, BOL!, NBG!, P!, TCD!, W), lectotype selected here.

Shrublets soft, sparse, low, erect to spreading, single-stemmed reseeders. *Branches*: main branches 50–400 mm long, occasional secondary branches 20–100 mm long; stems delicate, thin with dense, short, gland-tipped hairs to subglabrous, no infrapetiole ridges, internodes 3–10 mm long. *Leaves* 3-nate, spreading, elliptic-ovate,

TABLE 1.—Diagnostic characters in *Erica cavartica*, *E. amalophylla* and *E. cymosa*

	Bracteoles: position & type	Corolla length	Filaments	Anther appendages	Ovary	Fruit	Seeds
<i>E. cavartica</i>	basal, leaf-like	± 9 mm	narrow, straight, spoon-like	absent	glabrous	wrinkled	smooth
<i>E. amalophylla</i>	basal, leaf-like	± 3.5 mm	broadish, straight or slightly geniculate, spoon-like	absent	hirsute	smooth	smooth
<i>E. cymosa</i> subsp. <i>cymosa</i>	subapproximate to approximate, reduced	1.5–2.8 mm	broad, geniculate, not spoon-like	present	glabrous	smooth	shallowly alveolate
subsp. <i>grandiflora</i>	1/2 way to sub- approximate, reduced	3.5–5.5 mm	broad, geniculate, not spoon-like	present	sparsely pilose	smooth	shallowly alveolate

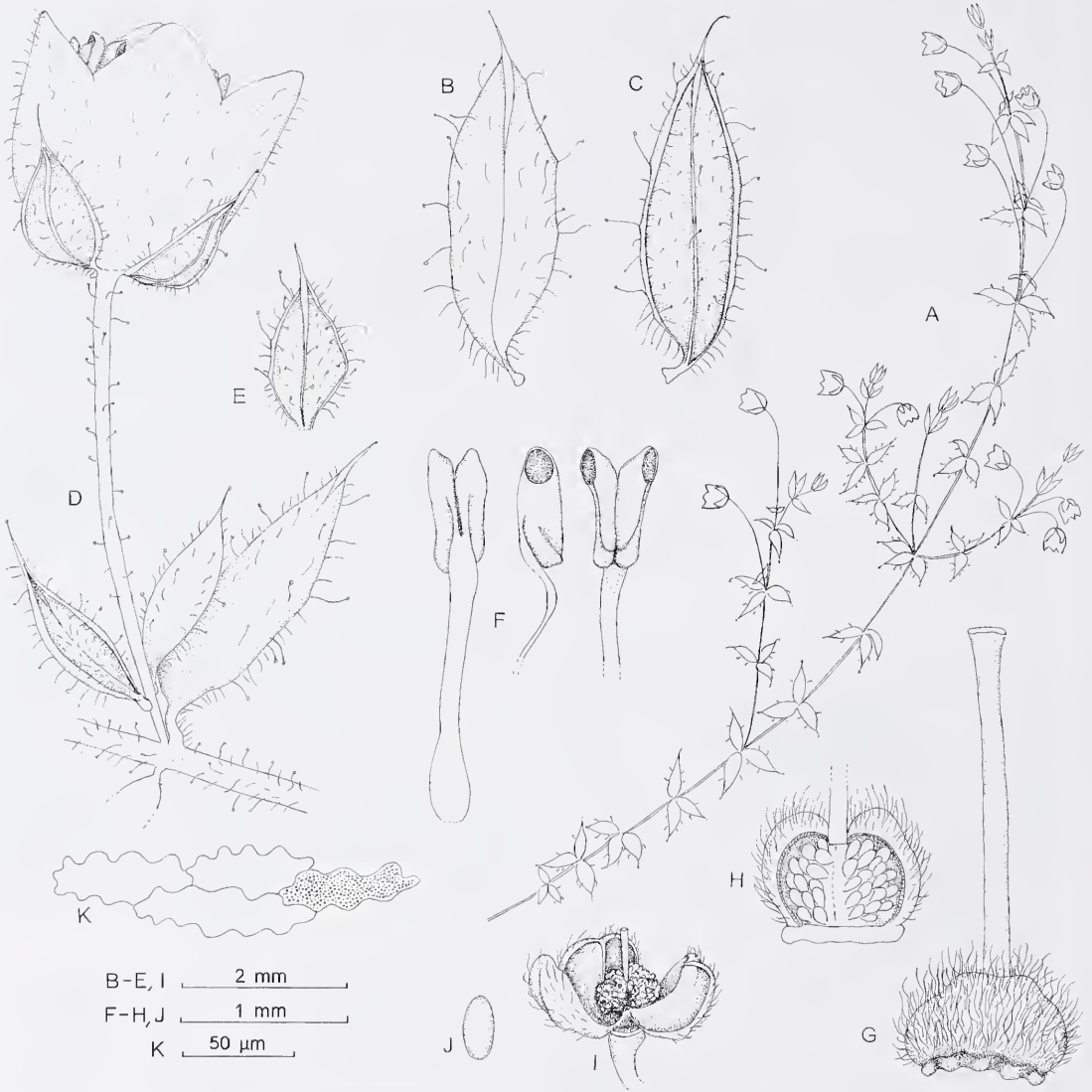


FIGURE 3—*Erica amatophylla*. A, flowering branch, natural size; B, leaf, adaxial surface; C, leaf, abaxial surface; D, flower; E, sepal; F, stamen, abaxial view, and anther in lateral and adaxial views; G, gynoecium; H, ovary opened laterally; I, capsule with one valve removed; J, seed; K, testa cells. All drawn from the type, *Esterhuysen 16612*. Scale bars: B-E, I, 2 mm; F-H, J, 1 mm; K, 50  $\mu$ m.

3.5–10.0  $\times$  1–3 mm, open-backed and flat, delicate, adaxially covered with sparse, short, simple hairs and a row of longer, gland-tipped hairs near margins, abaxially with dense, very short, simple hairs and a few scattered, longer, gland-tipped hairs, midrib thickened towards apex and extended into a stout seta terminated by a small gland and very short-haired, sparsely ciliate with gland-tipped hairs; petiole adpressed to spreading, 0.4–1.0 mm long, glabrous to fine-haired. *Inflorescence*: flowers 3-nate in 1–8 whorls, raceme-like towards ends of main and secondary branches, continuing vegetative growth on main branches but often terminating secondary branches; pedicel 4–12 mm long, glabrous or with short, gland-tipped hairs; bract not recalcrescent, leaf-like; bracteoles 2, from  $\frac{1}{2}$  way up pedicel to approximate to calyx, seldom opposite, narrowly ovate to narrowly elliptic, 0.9–2.0  $\times$  0.2–0.4 mm, with indumentum and

midvein same as in leaf. *Calyx* 4-partite, ovate to broadly ovate to broadly elliptic, 0.7–2.5  $\times$  0.4–1.1 mm, indumentum and structure like a leaf. *Corolla* 4-lobed, cyathiform to broadly urceolate, 1.5–5.5  $\times$  2.2–4.0 mm, covered with sparse, short, simple hairs, white to very pale pink or tinged with red; lobes 1–2 mm long, rounded to subacute, margins entire. *Stamens* 8, free, included; filaments elongate, very narrowly ovate, 2.0–2.5  $\times$  0.2 mm, with subapical S-bend, glabrous; anthers dorsally attached near base, bilobed, narrowly ovate in adaxial views, appendiculate; thecae erect, adpressed, ovate  $\pm$  0.7  $\times$  0.4 mm in lateral view, slightly prognathous at base, smooth, yellow, appendages at base of thecae or partially decurrent along apex of filament, pendulous, narrow,  $\pm \frac{2}{3}$  as long as thecae, pore  $\frac{1}{3}$ – $\frac{1}{2}$  length of theca; pollen shed in tetrads. *Ovary* 4-locular, slightly depressed obovoid, 0.6–1.5  $\times$  0.8–1.9 mm, emarginate,



glabrous or covered in upper half with sparse, short, simple hairs, nectaries present around base; ovules 35–50 per locule, spreading from placenta almost full length of columella; style manifest, 1.6–4.0 mm long, glabrous; stigma small, capitellate. *Fruit* a dehiscent capsule, valves splitting open  $\pm 40^\circ$  for  $\pm \frac{1}{2}$  their length, smooth, septa only on valves. *Seeds* ellipsoid,  $\pm 0.4 \times 0.2$  mm, rounded to angled, orange, shallowly alveolate; testa cells irregularly elongate,  $\pm 50\text{--}75 \times 15$   $\mu\text{m}$ , anticlinal walls thin, irregularly jigsawed, periclinal walls with numerous fairly large pits.

*Diagnostic features:* bracteoles positioned  $\frac{1}{2}$  way up pedicel to approximate to calyx, mainly much reduced but still leaf-like; corolla short to long,  $1.5\text{--}5.5 \times 2.2\text{--}4.0$  mm; filaments very elongate, narrowly ovate with sub-apical S-bend, without a basal, spoon-like expansion; anthers appendiculate; ovary glabrous or hairy; fruit smooth not wrinkled.

This species forms a close alliance with the two new species described above. It differs in having the bracteoles placed further away from the bract ( $\frac{1}{2}$  way up pedicel to approximate to the calyx and not basal) and the stamens with appendiculate anthers and filaments not spoon-like at the base (Table 1).

Variation in characters between the populations of *E. cymosa* are present. The most noticeable is in the size and shape of the corolla. There are however, two clear size groupings which occur in two disjunct distribution areas (Figure 2). These are also coupled with a difference in indumentum of the ovary. We have therefore decided to recognize these two regional variants at subspecific level.

Bentham (1839) described the species based on a Drège collection which had been provisionally named *E. cymosa* by Meyer who worked on and distributed many Drège collections. Bentham saw many collections from Berlin and usually cited these as 'v. s. sp. in herb. reg. Berol.' Since he did not cite this reference for *E. cymosa* he did not see his material there and must have relied solely on the rather scant material at Kew which he annotated. He noted in the protologue that he saw no cymes in the material, and unfortunately he proceeded to use Meyer's manuscript name '*cymosa*' for the species.

### 3a. subsp. *cymosa*

Guthrie & Bolus: 141 (1905); Dulfer: 77 (1965).

Illustration: Schumann & Kirsten: 122, t.1 (1992).

*Diagnostic features:* corolla  $1.5\text{--}2.8 \times 2.2\text{--}3.0$  mm; ovary glabrous.

The typical subspecies occurs in the mountains of the Du Toitskloof/Wellington/Wemmershoek area where it grows in moist places on cliffs (Figure 2). Where we have seen it, the plants grow on a ledge under an overhang in deep shade in a river gorge. *Flowering time:* October to March, one record in June.

3b. subsp. ***grandiflora*** *E.G.H.Oliv. & I.M.Oliv.*, subsp. nov., a subspecies typica floribus majoribus et ovario puberulo differt. Figura 4.

TYPE.—Western Cape. 3319 (Worcester): Worcester Div.; Blaaskloof, W slopes of Keeromsberg, 5000 ft [1 525 m], (–DA). 23 February 1958, *Esterhuysen 27590* (BOL, holo.; BM, E, K, MEL, MO, NBG, NY, P, PRE, S, W).

*Diagnostic features:* corolla larger,  $3.5\text{--}5.5 \times 3\text{--}4$  mm; ovary hairy (Figure 4; Table 1).

This subspecies occurs on the mountains in the Hex River Range just southwest of Ceres to near Worcester and on the Keeromsberg across the Hex River Valley (Figure 2). These populations are cut off from those of the typical subspecies by the much drier, lowland Worcester-Tulbagh Valley.

The plants are all recorded growing in rock crevices on overhanging rocks in shady, moist areas. One collection on Schurfteberg was described as on 'sheltered rather dry slightly earthy cliff face'.

Compton (1953) under the protologue of his *E. monantha*, noted that several collections by Elsie Esterhuysen 'may also belong to this species'. He noted that they possessed open-backed leaves and sepals which could be ascribed to their habitat preferences. These included two collections of this subspecies, *Esterhuysen 14719 & 15202* and the type of *E. amalophylla*. We regard Compton's *E. monantha* as being conspecific with *E. flacca* Benth. *Flowering time:* November to March.

### *Paratype material for subsp. grandiflora*

WESTERN CAPE.—3319 (Worcester): Ceres Div., Schurfteberg, 3500 ft [1 070 m], (–AD), 7-12-1948, *Esterhuysen 14719* (BOL, K, NBG, NY, PRE); Ceres Div., Mitchell Peak, 4000 ft [1 220 m], (–AD), 27-03-1949, *Esterhuysen 15202* (BOL, NBG, PRE); Ceres Div., Waaihoek Peak facing Tarantula Peak, 5800 ft [1 770 m], (–AD), 16-01-1961, *Esterhuysen 28737* (BOL, PRE); Worcester Div., Milner Peak, E side, 5000 ft [1 525 m], (–AD), 18-12-1948, *Esterhuysen 14938* (BOL, PRE); Worcester Div., Audensberg Ridge Peak, 2000 ft [610 m], (–CB), 1-01-1950, *Esterhuysen 16744* (BOL, NBG).

### *Specimens examined for subsp. cymosa*

WESTERN CAPE.—3319 (Worcester): Du Toitskloof, (–CA), *Drège 1185* (K, lecto.; BM, BOL, NBG, P, TCD); *ibid.*, *Drège SAM10592* (SAM); *ibid.*, 2000–3000 ft [600–900 m], October, *Drège s.n.* (BOL); Malbrokskloof, 2500–3000 ft [760–900 m], IIIAe, (–CA), 20-02-1828, *Drège s.n.* (P); Seven Sisters above Groen Kloof, 3500 ft [1 070 m], (–CA), 14-01-1951, *Esterhuysen 18322* (BOL); kloof between Krom River Peak and Krom River Dome, 3000 ft [915 m], (–CA), 30-12-1958, *Esterhuysen 28062* (BOL, K); *ibid.*, 4000 ft [1 220 m], 26-10-1960, *Esterhuysen 28687* (BOL, NBG); Haelhoek Sneekop overlooking Wemmershoek Valley, 3500 ft [1 070 m], (–CA), 14-03-1959, *Esterhuysen 28225* (BOL, PRE); Klein Drakenstein Mtns, Donkerkloof,  $\pm 3000$  ft [915 m], (–CA), 31-06-1960, *Esterhuysen 28435* (BOL, K, PRE); ridge between Witteberg and Molenaarsberg, 4500 ft [1 370 m], (–CA), 27-12-1960, *Esterhuysen 28693* (BOL); Du Toitskloof Mtns, upper Krom River SE of New Year's Peak, 3500 ft [1 070 m], (–CA), 22-12-1959, *Oliver 418* (NBG) [voucher for Schumann & Kirsten: 122, t. 10, 1992]; *ibid.*, 1 000 m, 7-01-1961, *Oliver 1144* (NBG); Seven Sisters, Wellington, (–CA), 10-1931, *Stokoe 6695* (BOL).

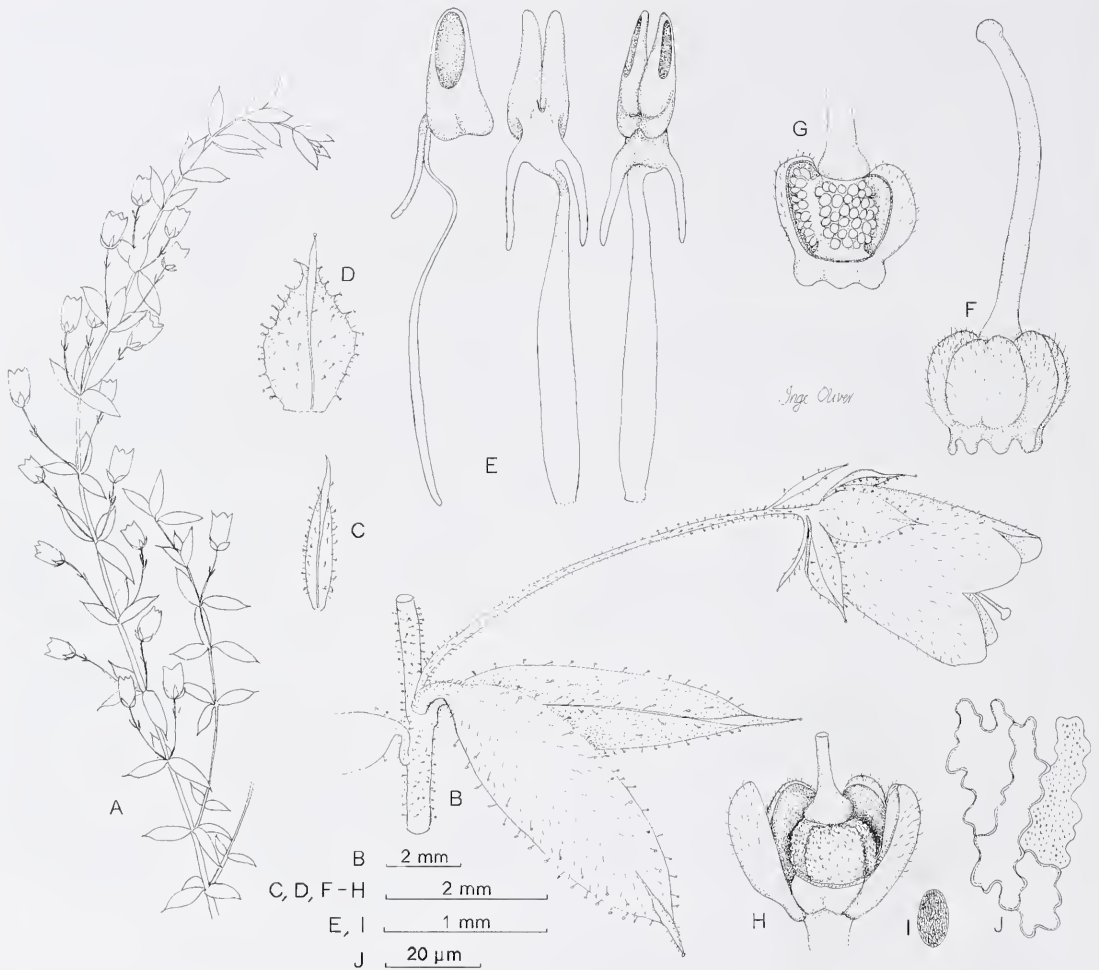


FIGURE 4.—*Erica cymosa* subsp. *grandiflora*. A, flowering branch, with bracteoles mostly in halfway position, natural size; B, flower, with bracteoles subapproximate; C, bracteole; D, sepal; E, stamen, lateral, back and front views; F, gynoecium; G, ovary opened laterally; H, capsule; I, seed; J, testa cells. All drawn from the type, *Esterhuysen 27590*. Scale bars: B–D, F–H, 2 mm; E, I, 1 mm; J, 20  $\mu$ m.

#### LITTLE KAROO SPECIES

4. *Erica schelpeorum* E.G.H.Oliv. & I.M.Oliv., sp. nov., foliis 4-natis, ramis, foliis, bractea bracteolisque pilis glandulosis, bractea non recalcrescenti, inflorescentibus umbellatis, pedicello longo (5–9 mm), calyce sine glandibus, corolla glabra, antheris exsertis muticis vel ealearibus minutis dignoscenda. Figura 5.

TYPE.—Western Cape, 3321 (Ladismith): Swartberg Mtns, northern foothills due N of highest point of road before descent into Die Hel, 4 000 ft [1 220 m], 6-05-1963, *Oliver STE32108* (NBG, holo.; BM, BOL, K, MO, NY, PRE).

Shrub erect, much branched, twiggy, 0.5–1.5 m tall, grey, single-stemmed resceder. *Branches*: numerous, main branches 30–120 mm long and secondary branches 10–30 mm long; internodes 2–5 mm long; stem with short, spreading, simple hairs and fewer, long, gland-tipped hairs admixed. *Leaves* 4-nate, subspreading, incurved but not imbricate, oblong, 4–5  $\times$  0.8–1.2 mm,

with rounded margins, obtuse, finely short-haired on both surfaces, abaxially with scattered, long, gland-tipped hairs admixed, sulcus narrow, open at base; petiole  $\pm$  0.8 mm long, short-haired. *Inflorescence*: flowers 4-nate in 1–4 whorls umbel-like at apex of most main and secondary branches; pedicel 5–9 mm long, finely short-haired with a few, long, gland-tipped hairs admixed; bract not recalcrescent, 2–3  $\times$  0.6 mm, otherwise like leaf, green or pinkish red; bracteoles 2, just above mid position on pedicel, 1.5–2.2  $\times$  0.3–0.6 mm, like miniature leaf with long petiole. *Calyx* 4-partite; segments broadly elliptic,  $\pm$  3  $\times$  1.5 mm, adpressed to corolla, subacute, margins entire at base, slightly toothed/lobed in upper half, glabrous with upper sulcate region short-haired, purple-red often with green apical portion, sulcus narrow,  $\frac{1}{3}$  length of segment. *Corolla* 4-lobed, globose-urceolate, 4.0–4.5  $\times$  3–4 mm, glabrous, whitish pink base to dark pink apex; lobes suberect to erect,  $\pm$  1  $\times$  1.5 mm, broadly rounded, entire to slightly erose. *Stamens* 8, exserted; filaments free, linear-oblong,  $\pm$  2.6  $\times$  0.25 mm, slightly widened towards base, straight or very slightly geniculate subapically, glabrous,



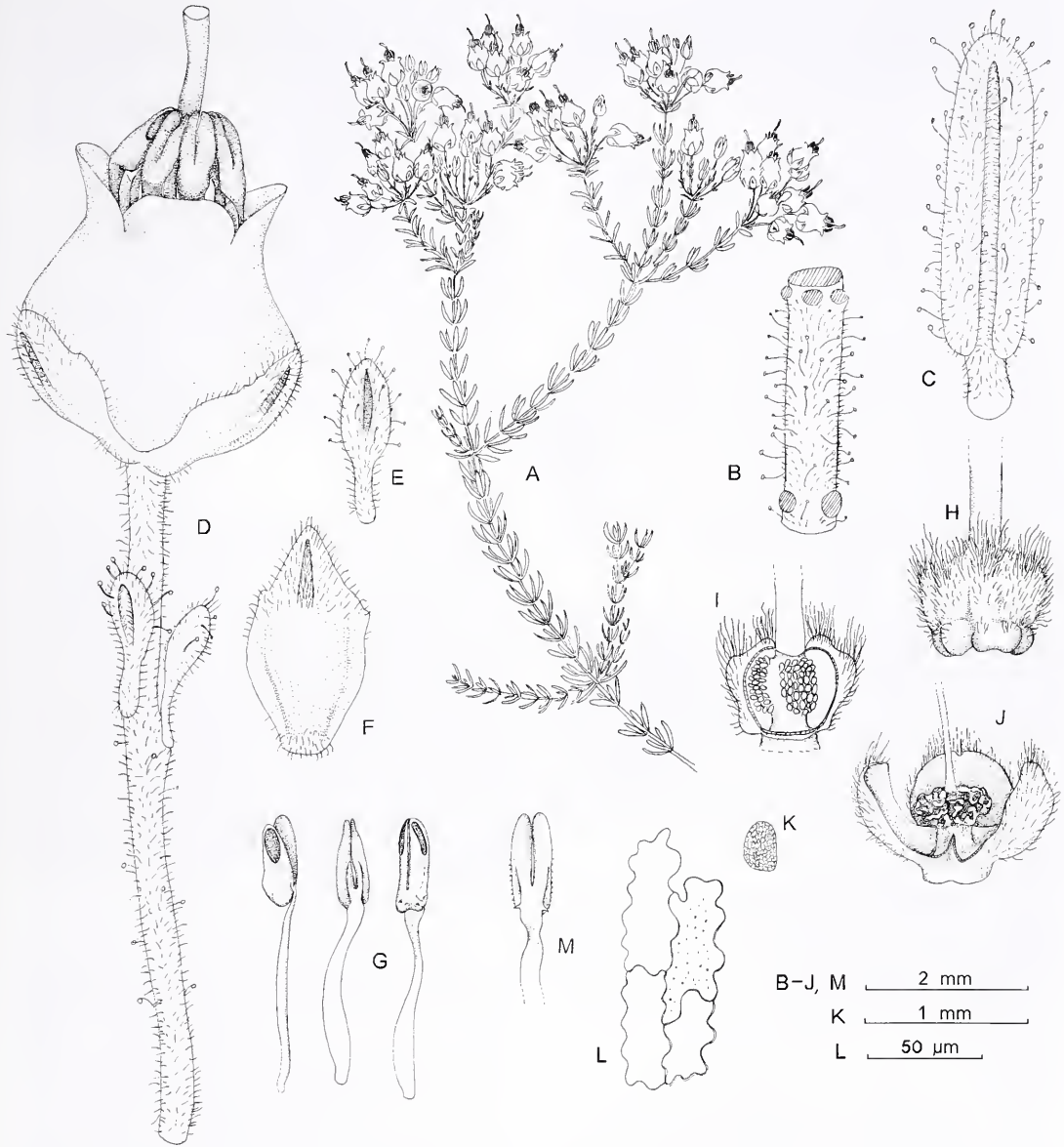


FIGURE 5.—*Erica schelpeorum*. A, flowering branch, natural size; B, stem, with leaves removed; C, leaf; D, flower; E, bracteole; F, sepal; G, stamen, side, back and front views; H, ovary; I, ovary opened laterally to show ovules and placentae; J, capsule with one valve removed; K, seed; L, testa cells; M, anther variant with appendages. A–I drawn from the *Oliver 11863* & *11879*, M from *Vlok 2454*. Scale bars: B–J, M, 2 mm; K, 1 mm; L, 50  $\mu$ m.

white; anthers dorsally attached near base, lanceolate to oblong in adaxial view, bipartite, minutely appendiculate or muticous; thecae lanceolate in lateral view,  $\pm 1.1 \times 0.4$  mm, adpressed to slightly spreading, smooth, dark brown, spurs (when present) minute, pore  $\pm \frac{1}{3}$  length of theca; pollen in tetrads. *Ovary* 4-locular, very broadly obovoid,  $1.5 \times 1.7$  mm, emarginate, 8-lobed, hairy with hairs longer at apex of lobes, with large nectaries around base; ovules 30–40 per locule spreading from placenta in upper  $\frac{3}{4}$  of locule; style exserted,  $\pm 5$  mm long, glabrous, white; stigma simple truncate. *Fruit* a dehiscent capsule,  $\pm 1.8 \times 2.8$  mm, valves splitting  $\frac{3}{4}$  their length to  $45^\circ$  angle, septa only on valves, placentae

large. *Seed* small, obovoid, rounded to sub-angular,  $\pm 0.3 \times 0.2$  mm, orange; testa shallowly reticulate, not thick, cells  $50\text{--}70 \times 25$   $\mu$ m, anticlinal walls slightly thickened, jigsawed, inner periclinal walls sparsely pitted. *Flowering time*: this would appear to be autumn to early winter (May to July) but can be earlier when summer rains have occurred. This is certainly the case with the Kykoe population which was in full flower for the Viviers & Vlok specimen in July and the Schumann specimen in May but just past peak flowering for us in early March. However, in the latter case only a few of the shrubs had flowered, with the others not having produced any flowers at that stage. Figure 5.

**Diagnostic features:** leaves 4-nate; gland-tipped hairs on stems, bract and bracteoles but not sepals; bract non recaulescent (bract = leaf); pedicel long, 5–9 mm; corolla glabrous; anthers exserted with no, or only minute appendages.

This new species is allied to several species in §*Ephebus*—*E. hirta* Thunb. (*E. sphaeroidea* Dulfer), *E. perlata* Sinclair, *E. tradouwensis* Compton, and also to *E. armata* Klotzsch ex Benth. (§*Myra*), *E. mitchellensis* Dulfer (§*Orophanes*) and *E. strigosa* Sol. (§*Ceramia*). These species are widely scattered through the current poor, i.e. unnatural, system of sections in the genus.

It is most similar to *Erica hirta*, *E. perlata* and *E. tradouwensis* in having the long pedicels and flowers with slightly exserted anthers. *E. hirta* differs in the short spike-like inflorescence (not umbel-like), the hairy corolla and 3-nate leaves, *E. perlata* in the hairy corolla, the subopen-backed, spreading leaves and the spurred anthers, and *E. tradouwensis* in the 3-nate leaves which are slightly open-backed, the hairy corolla and the eglandular, long hairs on the stems and leaves.

*Erica schelpeorum* was stated above as being similar to three other species in other sections. With *E. armata* it shares the bract on the main axis (non recaulescent), the 4-nate leaves, similar glands and umbel-like inflorescence but that species has larger, hairy flowers, pedicel shorter than the corolla and longer anther appendages. *E. mitchellensis*, which is similar to *E. armata*, has a recaulescent bract and inflorescence of only a single whorl. *E. strigosa* has the non recaulescent bract and glabrous corolla, but differs in having a spike-like inflorescence and short pedicel.

This species was first collected in 1954 by Mrs Sybilla Schelpe (1917–2001) while on a field trip with her husband, Prof. Ted Schelpe (1924–1985), who was the lecturer in taxonomy for both of us during our student years at the University of Cape Town. We thus take this opportunity of honouring them both in naming this species which was discussed with Sybilla shortly before her death.

*Erica schelpeorum* is widespread on mountains and hills in and bordering the Little Karoo (Figure 6). In all cases where we have seen the species, it occurs in dry, arid areas usually associated with a dry watercourse. Despite the high altitude of the type collection, the plants there were growing in arid renosterveld vegetation on the

southern slopes of the northern foothills to the main range of the Great Swartberg. In the Kykoe locality which was shown to us by Jan Vlok and which is the same population as *Viviers & Vlok 184* and *Schumann 684*, the plants were growing in renosterveld vegetation on shale/clay with a thin overlay of quartzite pebbles washed down in a small dry watercourse.

All the species mentioned as being similar in some respects, do not occur sympatrically with *E. schelpeorum*, they all occur in the region to the southwest from the Hex River Mountains to the Cape Peninsula eastwards as far as the Langeberg, just east of Swellendam. *Erica hirta* and *E. tradouwensis* are both low altitude species with the former growing on clay/gravel slopes sometimes on the border between dry fynbos and renosterveld vegetation in the Malmesbury, Stellenbosch and Genadendal areas.

#### Paratype material

**WESTERN CAPE.**—3321 (Ladismith): Swartberg, in ravine between Kliphuisvlei and Gamkaskloof, 1 200 m, (–BD), 7-05-1989, *Vlok 2112* (NBG); Calitzdorp area, Gamka Mountain Reserve, upper Tierkloof, 500 m, (–DB), 7-05-1983, *P. & J. Cattell 240* (BM, BOL, K, MO, NBG, NY, PRE, S); *ibid.*, N slopes of Dwarsberg, 900 m, (–DB), 8-09-1987, *Allardice 1730* (NBG). 3322 (Oudtshoorn): Swartberg Pass, N side, 3500 ft [1 060 m], (–AC), 12-02-1954, *A.S.L. Schelpe 98* (BOL); Great Swartberg, Meiringspoort, 2 100 ft [640 m], (–BC), 23-06-1997 (fruiting), *Oliver 10820* (NBG); Groot Swartberg, eastern end at N base of Snyberg, 4000 ft [1 220 m], (–BD), 12-03-1991, *Vlok 2454* (BOL, NBG); Kammanassie Mtns, Klein Plaas River Valley, 3600 ft [1 100 m], (–DA), 10-08-1983, *Mathews 1170* (K, NBG, P, PRE); Ghwernaberg, above Kykoe, 600 m, (–DD), 11-01-2001, mainly in bud, *Oliver 11863* (NBG); *ibid.*, 7-03-2001, *Oliver 11879* (NBG); Potjiesrivierhoogte Pass, southern foot, 550 m, (–DD), 25-05-1989, *Schumann 684* (NBG); *ibid.*, next to national road on southern slope, (–DD), 3-07-1987, *Viviers & Vlok 184* (BM, K, NBG, NY, PRE). 3323 (Willowmore): Antoniesberg, S side, ± 1 000 m, (–AD), 10-03-2001, *Van Wijk 2302* (NBG, SCHG).

5. *Erica lithophila* E.G.H.Oliv. & I.M.Oliv., sp. nov., *Ericae kirstenii* E.G.H.Oliv. proxima sed fruticulo parvulo, ovulis 20–30 in quoque loculo non ± 60, erectis non effusis vel pendulis, antherarum calcaribus angustioribus, testa parietibus anticlinalibus pertenuibus non percrassis multo undulatis dignoscenda. Figura 7.

**TYPE.**—Western Cape. 3322 (Oudtshoorn): Swartberg at Meiring's Poort, 5000 ft [1 524 m], (–BC), 16 October 1955, *Esterhuysen 24865* (BOL, holo.; K!).

Small, brittle, delicate shrublets, 20 × 20–80 × 50 mm, rarely 120 mm in diam., erect and compact to slightly

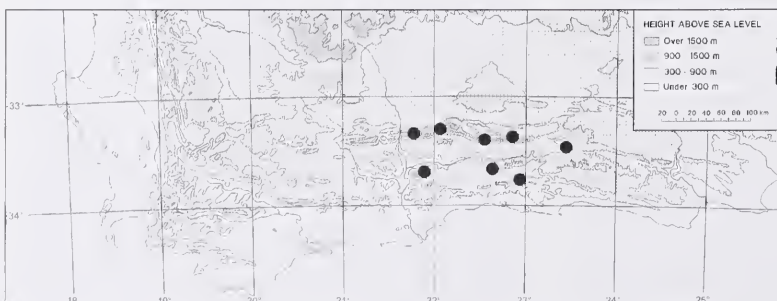


FIGURE 6.—Known distribution of *Erica schelpeorum*.



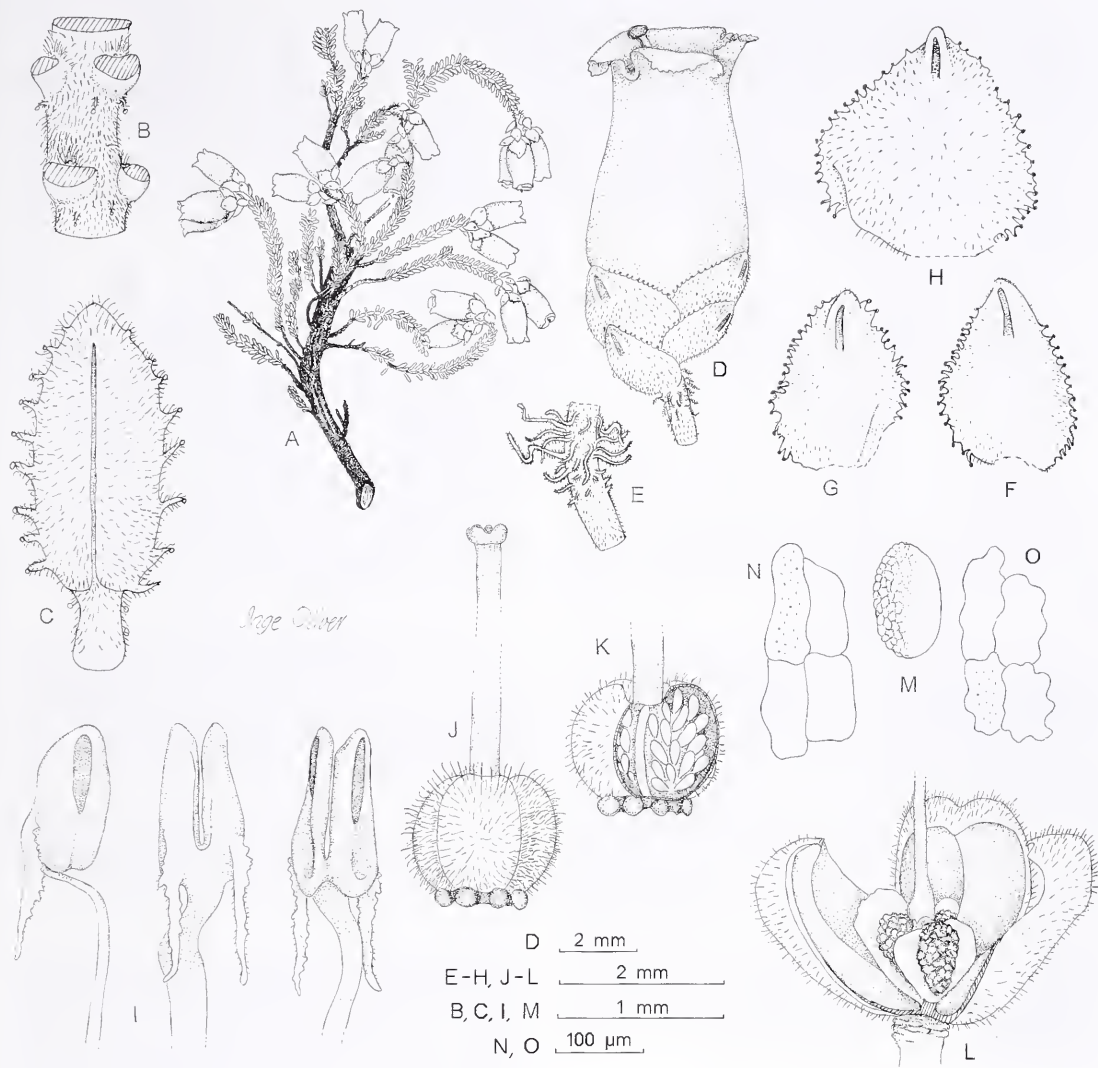


FIGURE 7.—*Erica lithophila*. A, flowering branch, natural size; B, stem with leaves removed; C, leaf; D, flower; E, pedicel; F, bract; G, bracteole; H, sepal; I, stamen, side, back and front views; J, gynoecium; K, ovary partially opened laterally to show ovules; L, capsule with one valve removed; M, seed; N, outer portion of anticlinal testa cell walls; O, inner portion of anticlinal testa cell walls. A–K, drawn from Vlok 2476; L–N, from Oliver 11552; O from Oliver 11833. Scale bars: B, C, I, M, 1 mm; D, E–H, J–L, 2 mm; N, O, 100  $\mu$ m.

spreading, single-stemmed reseeder. *Branches*: thick, woody, basal stem with numerous main branches, 10–15 mm long, secondary branches few,  $\pm$  2 mm long; stems with white, short, dense, simple hairs and a few plumose hairs; internodes very short. *Leaves* 2- or 3-nate, imbricate, subspreading, elliptic, 2.5–3.0  $\times$  0.8 mm, abaxially rounded, adaxially flattened, covered with dense, grey-white, short, simple hairs, margins with short, plumose, gland-tipped hairs, sulcus narrow open at base; petiole  $\pm$  0.4 mm long, short-haired to sparsely hairy, margins with simple hairs and/or short, gland-tipped hairs. *Inflorescence*: flowers 1–3 in 1 whorl at ends of main branches and very rarely, secondary branchlets; pedicel  $\pm$  2 mm long, red, covered with very short, fine hairs and in upper half also with stouter, white, crisped, plumose hairs, 0.4–1.0 mm long, these with or without an apical gland; bract partially recaulescent about  $\frac{2}{3}$  up pedicel, ovate,  $\pm$  2.2  $\times$  1.7 mm, subacute, pink, sparsely covered with very

short, fine, simple hairs, unevenly toothed, teeth gland-tipped, sulcus narrow,  $\pm$   $\frac{1}{3}$  length of bract; bracteoles 2, approximate to calyx, slightly lopsided, otherwise same as bract. *Calyx* 4-partite, segments imbricate, broadly ovate,  $\pm$  2.8  $\times$  2.8 mm, subacute, pink, otherwise like bract. *Corolla* 4-lobed, urceolate,  $\pm$  7.5  $\times$  4 mm, pink, glabrous; lobes recurved, broadly rounded,  $\pm$  1.8  $\times$  0.7 mm, erose sometimes with very broad, plumose hairs at base. *Stamens* 8, included, free; filaments linear,  $\pm$  3  $\times$  0.4 mm, slightly geniculate below theca, white, glabrous; anthers bipartite, ovate in adaxial view, appendiculate; thecae oblong, 0.9–1.2  $\times$  0.9 mm in lateral view, dark brown, smooth, appendages elongate, narrow-lanceolate,  $\pm$  1 mm long, strigulose, irregularly toothed, pore  $\pm$   $\frac{1}{2}$  length of theca; pollen shed in tetrads. *Ovary* 4-locular, subsphaeroid,  $\pm$  1.8  $\times$  1.5 mm, emarginate, completely covered with longish, spreading, simple hairs, with well-developed nectaries around base; ovules 25–30 per locule,

erect to suberect on a complete central placenta; style included,  $\pm 6$  mm long, straight, glabrous; stigma manifest capitellate. *Fruit* a dehiscent capsule,  $\pm 3 \times 4.2$  mm, valves splitting to base and  $45^\circ$ , septa mainly on columella, hard, woody. *Seeds* ellipsoid,  $\pm 0.7 \times 0.4$  mm, slightly flattened laterally; testa colliculate, yellow-orange, cells  $\pm$  oblong,  $70\text{--}100 \times 50$   $\mu\text{m}$ , outer part of anticlinal walls straight to slight undulate, inner part irregularly undulate, inner periclinal walls sparsely and finely pitted. *Flowering time*: August to November. Figure 7.

**Diagnostic features:** shrublets very small with flowers relatively large compared to the plant and leaves; leaves grey; pedicel with long, plumose hairs in upper part; anther appendages narrow; ovules 20–30 per locule, erect; seeds with delicate testa having thin anticlinal walls.

This new species is most closely related to *E. kirstenii* E.G.H.Oliv. (Oliver & Oliver 2000) which is distinguished by the much larger stouter shrubs, leaves  $\pm$  twice as long, pedicel long and curved with short plumose hairs all over, ovules  $\pm 60$  and not erect and testa cells with thick anticlinal walls.

*Erica lithophila* occurs on the eastern parts of the Great Swartberg Range in the Meiringspoort area and on the Kammanassie Mountains just to the south where it is confined to high altitudes (Figure 8). The species is easily overlooked due to the small size of the plants with very old gnarled plants often only  $30 \times 30$  mm and growing. The habitat is rock crevices in large rocks usually with no soil and north-facing. The largest plant we have seen was growing in some humus in a vertical crack facing east and was open and  $\pm 120$  mm in diameter. In these dry, rocky habitats, the shrublets are often cryptic, melting in with the lichen-covered rock. In younger plants the flowers at  $\pm 7.5$  mm long, are rather disproportionately large for a plant only 20 mm in diameter. The habitat preference provides the specific epithet for the species—*lithos* = rock (Greek), *-philos* = loving (Greek).

*Erica kirstenii* is confined to rocky places on the Klein Swartberg in the region of Ladismith and Seweweekspoort  $\pm 100$  km to the west of the distribution range of *E. lithophila*.

There are several other species that grow in rocky places and that have similar flowers with large, petaloid

bracts, bracteoles and sepals edged with teeth or stout plumose hairs—*E. taylorii* E.G.H.Oliv. & I.M.Oliv. (Oliver & Oliver 2001) and *E. modesta* Salisb. The former occurs in two very disjunct regions, the Cederberg and the Klein and central Groot Swartberg and produces large spreading mats on rocks at high-lying altitudes, whereas the latter occurs along the summit ridges in the Riviersonderend Mountains and forms a taller, erect shrub up to 0.75 m.

#### Paratype material

WESTERN CAPE—3322 (Oudtshoorn): Swartberg, Spitzkop neck to the east, 1 600 m, (–AD), 15-04-2000 (fruiting), *R. Taylor s.n.* (NBG); *ibid.*, 5000 ft [1 524 m], 9-03-1991 (fruiting), *Vlok s.n.* (NBG); Blesberg, 6000 ft [1 828 m], (–BC), 17-10-1955, *Esterhuysen 24934* (BOL); *ibid.*, N & E slopes, 2 060 m, 13-07-2000 (flowers & fruiting), *Oliver 11552* (NBG); Swartberg Mtns, N slopes above Vrolijkheid E of Meiringspoort, 5200 ft [1 584 m], 16-08-1991, *Vlok 2476* (NBG); Kammanassie Mtns near Mannetjesberg, 1 700 m, (–DB), 7-11-1995, *Hitchcock K73* (NBG); Mannetjesberg Peak, N slopes, 6200 ft [1 890 m], (–DB), 2-10-1971, *Oliver 3612* (NBG); Kammanassie Mtns due N of Buffelsberg, 1 500 m, (–DB), 9-01-2001 (fruiting), *Oliver 11807* (NBG); Kammanassie Mtns, Molenrivier 114, W of Mannetjesberg, 1 840 m, (–DB), 9-01-2001 (fruiting), *Oliver 11833* (NBG).

**6. *Erica umbratica* E.G.H.Oliv. & I.M.Oliv., sp. nov.**, fruticula tenello fragili pendulo, foliis 3-natis effusis, pilis brevibus glandulosis et glande magno apicali, floribus viscidis, pedicello longo, sepalis glandibus sessilibus marginalibus, calcaribus antherarum longis undulatis, ovario pubenti dignoscenda. Figure 9.

**TYPE.**—Western Cape, 3322 (Oudtshoorn); Meiring's Poort, northern end near Wadrif, 600 m, (–BC), 5 January 2001, *E.G.H. & I.M. Oliver 11757* (NBG, holo.; K, PRE).

Shrublet delicate, brittle, pendulous, 200–500 mm long, single-stemmed reseeder. *Branches*: main branches 200–400 mm long, with numerous secondary branches, 10–80 mm long, these not at each node, occasional, short, tertiary branchlets; stems sparsely hairy with short, spreading, simple hairs and stalked glands. *Leaves* 3-nate, subspreading to spreading to  $90^\circ$ ,  $5\text{--}7 \times 0.8$  mm, rounded on both sides, margins rounded to slightly acute, sulcus narrow, sparsely hairy on both surfaces with short-stalked glands on margins, apex tipped with solitary large gland, open at base, with occasionally at base of each lateral branch, 1–3(–5) whorls of small brown bract-like leaves; petiole  $\pm 0.6$  mm long, hairy on both

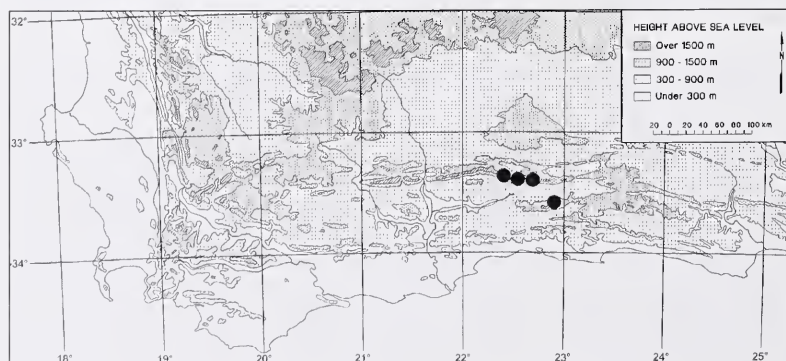


FIGURE 8.—Known distribution of *Erica lithophila*.



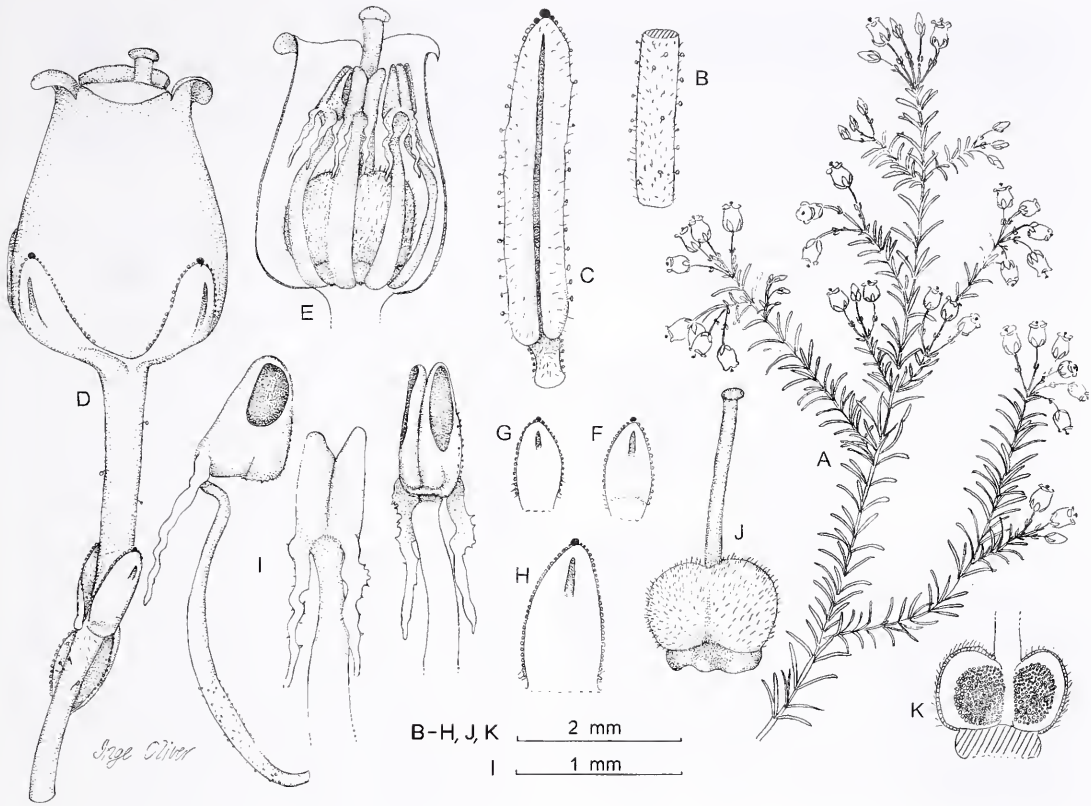


FIGURE 9.—*Erica umbratica*. A, flowering branch, natural size; B, stem; C, leaf; D, flower; E, flower opened laterally; F, bract; G, bracteole; H, sepal; I, stamen, side, back and front views; J, gynoecium; K, ovary opened laterally to show ovules and placentae. All drawn from the type collection, *Oliver & Oliver 11757*. Scale bars: B–H, J, K, 2 mm; I, 1 mm.

sides, glands on margins. *Inflorescence*: flowers 3-nate in 1 or 2 whorls, umbel-like at ends of main and secondary branches; pedicel 6–7 mm long, pink, glabrous with a few scattered short-stalked glands and simple hairs at attachment of bract and bracteoles; bract partially recalcrescent,  $\pm \frac{1}{4}$  way up pedicel, ovate,  $\pm 1.2\text{--}1.4 \times 0.6$  mm, margins lined with sessile glands, apex with larger, red gland, otherwise glabrous, greenish; bracteoles 2,  $\frac{1}{3}\text{--}\frac{1}{2}$  way up pedicel,  $\pm 1.4 \times 0.6$  mm, otherwise like bract. *Calyx* 4-partite, adpressed to corolla; segments ovate,  $\pm 2 \times 1$  mm, margins lined with sessile very viscid glands, the terminal one larger and dark red, otherwise glabrous, green. *Corolla* 4-lobed, ovoid,  $\pm 4 \times 3$  mm, glabrous, viscid, white; lobes recurved,  $\pm 0.7 \times 1.2$  mm, rounded, margins entire. *Stamens* 8, included, free; filaments linear,  $\pm 5 \times 0.5$  mm, slightly widened at base, subapically geniculate, spiculate near base, otherwise glabrous; anthers bipartite, dorsally attached near base, lanceolate to oblong in adaxial view, appendiculate; thecae ovate in lateral view,  $\pm 1.8 \times 1.1$  mm, finely spiculate, orange-yellow, appendages elongate, narrowly lanceolate,  $\pm 2.2 \times 0.2$  mm, slightly zigzagged, sparsely toothed and with a few short, simple hairs, pore  $\pm \frac{1}{2}$  length of thecae; pollen in tetrads. *Ovary* 4-loculate, spherical,  $\pm 1.5 \times 1.8$  mm, emarginate, short-haired, with large basal nectaries; ovules 80–100 per locule, lateral and spreading on large, bulbous placenta the full length of locule; style  $\pm 2.4$  mm long, just exserted, glabrous;

stigma capitellate. *Fruits* not seen. *Flowering time*: this is variable and possibly determined by rainfall, which is mainly in winter but also as summer showers. Flowers do not seem to be profuse on the plants. Figure 9.

*Colour illustrations*: Schumann & Kirsten: 251, t. 10 & t. 11 (1992).

*Diagnostic features*: delicate, brittle, pendulous shrublet; leaves 3-nate, spreading (up to 90°), delicate; pedicel long (6–7 mm); flowers viscid; anther appendages long, narrow, zigzagged and irregularly toothed; ovary short-haired.

This new species shares similarities with a range of viscid-flowered species such as *E. carduifolia* Salisb., *E. nubigena* Bolus, *E. ixanthera* Benth., *E. wittebergensis* Dulfer, and two undescribed species—one from the Kouga Mountains (*Esterhuysen 10673, 27097*), the other from the northern side of the Swartberg Pass (*Schumann 798 and Vlok 2502*). With these it shares long, 3-nate leaves mostly with sticky glands, often spreading and caducous, bract-like leaves at base of flowers and side branches, long pedicel with few to many glands, similar sized and positioned bract and bracteoles, large sessile marginal glands on the sepals, long anther appendages, and ovary with large placenta bearing numerous ovules producing small seeds. It differs in its growth form, being

pendulous with thin, very brittle branches, much longer zigzagged and irregularly toothed anther appendages and short-haired ovary. Each of the species has rather specific leaves.

Most of the other species grow in shaded, moist places often on southern slopes, *E. nubigena* and *E. carduiifolia* at high altitudes, *E. ixanthera*, *E. sp. nov.* (Kouga) and *E. umbratica* at a much lower altitude. *Erica sp. nov.* from the Swartberg Pass is the odd one out as it grows on dry, rocky slopes in open veld on the northern side of the Swartberg and forms erect, woody shrublets.

*Erica umbratica* has rather viscid flowers which easily collect dirt on them in the very windy conditions that prevail in Meiringspoort. This made Schumann in frustration, refer to this new species as *Erica* "puer-sordidus"—the dirty boy, when trying to produce perfectly clean material for photographing (Schumann & Kirsten 1992).

*Erica umbratica* is known only from a few small populations in Meiringspoort (Figure 10) where it grows on very large, shaded rocks, just above the main stream which runs through the poort. It could be postulated to have evolved with the formation of the poort. The plants we have studied grow in cracks and on ledges sheltered under overhangs on a large rocky outcrop where they receive very little direct sunlight. We have thus chosen the name to reflect this habitat, *umbraticus* = of the shade (Latin). Due to the inaccessible location, material for study is very limited.

The discovery of this rare species was made by Jan Vlok who has an eye for recognizing unusual and interesting plants—the plants look so unlike an *Erica* species, and more like some members of the family Asteraceae such as *Stoebe*.

#### Paratype material

WESTERN CAPE.—3322 (Oudtshoorn): Swartberg Mtns, Meiringspoort, 550 m, 8-08-1987, (–BC), Schumann 548 (NBG); *ibid.*, near Herriesklip, (–BC), 15-04-1986, Vlok 1460 (NBG; PRE); *ibid.*, near Waterfall picnic area, (–BC), 1 900 ft [580 m], 26-06-1990, Vlok 2312 (NBG).

7. *Erica annalis* E.G.H.Oliv. & I.M.Oliv., sp. nov., a specibus nobis notis bene distincta, foliis 4-natis paucis spiculis, inflorescentia non spicata, pedicello comparate longo (10–15 mm), bractea bracteolisque parva remota, corolla perpubenti, filamentis styloque sparse

pilosis dignoscenda. Figura 11.

TYPE.—Western Cape. 3322 (Oudtshoorn): Kammassie Mountains, Perdekloof, northern foothills of Mannetjiesberg above Buffelsklip, 820 m, (–DB), 3 September 2001, E.G.H. & I.M. Oliver 11929 (NBG, holo.; BOL, K, NY, PRE).

Sparingly branched, erect to spreading shrub, 0.2–1.0 m tall, often with gnarled old basal stems/branches, single-stemmed. *Branches*: main branches 50–100(–200) mm long; secondary branches vestigial; stems grey, very finely short-haired, sometimes with a few gland-tipped hairs admixed; internodes up to 5 mm long. *Leaves* 4-nate, 12–15 × 1 mm, subspreading to spreading, recurved, glabrous or with a few, sparse, basal hairs and a few spicules abaxially, ± circular in cross section, sulcus narrow, open at base; petiole 1 mm long adpressed, fine-haired, yellow. *Inflorescence*: 1–3 flowers in a single whorl at ends of main and secondary branches, subspreading to spreading; pedicel 10–15 mm long, finely short-haired with numerous longer, stalked, red, gland-tipped hairs admixed, green to reddish; bract partially recalcrescent in basal position, oblong, ± 1.7 × 0.4 mm, finely short-haired, margins with minute sessile glands, green-brown, sulcus minute; bracteoles 2 in lower half of pedicel, otherwise same as bract but sulcus often absent. *Calyx* 4-partite; segments lanceolate, ± 5 × 0.4 mm, not laterally imbricate, fine-haired with glandular margins, green to reddish; sulcus ± 1/2 length of segment, narrow. *Corolla* 4-lobed, ± 25 × 4 mm, tubular, funnel-shaped, curved with slight constriction above ovary, with scattered, short and a few longer, simple hairs, bright orange-red; lobes ± 3 × 3 mm, subacute, margins entire, spreading to recurved. *Stamens* 8, free, manifest to exerted; filaments linear, straight, very sparsely pilose, white with pale red apex; anthers bilobed, dorsally attached ± 1/3 way up, narrowly oblong-elliptic in adaxial view, muticous; thecae narrowly oblong and ± 5 × 0.6 mm in side view, smooth, golden brown to reddish brown, pore ± 1/3 length of theca; pollen in tetrads. *Ovary* 4-locular, cylindrical to narrowly ellipsoid, ± 3.3 × 2.2 mm, 4-lobed with rounded apex, covered with dense, long, erect hairs, nectaries present around base; ± 35 ovules per locule, spreading from full-length placenta; style ± 27 mm long with a few hairs towards base, white, reddish towards apex; stigma truncate simple, reddish. *Fruit* a dehiscent capsule, ± 5 × 4.5 mm, obovoid, hard and woody, valves splitting 35° for 3/4 their length, placenta whole length of capsule, septum mostly on valve. *Seeds* ± 1 × 0.7 mm, broadly ellipsoid with one side slightly flattened, brown; testa slightly alveolate, cells ± hexagonal ± 100 × 75 µm, anticlinal

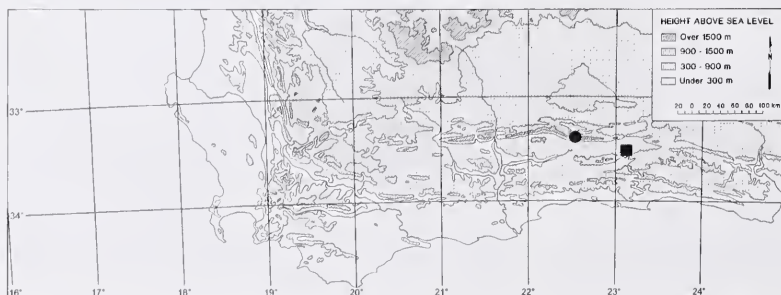


FIGURE 10.—Known distribution of *Erica umbratica*, ●, and *E. annalis*, ■.



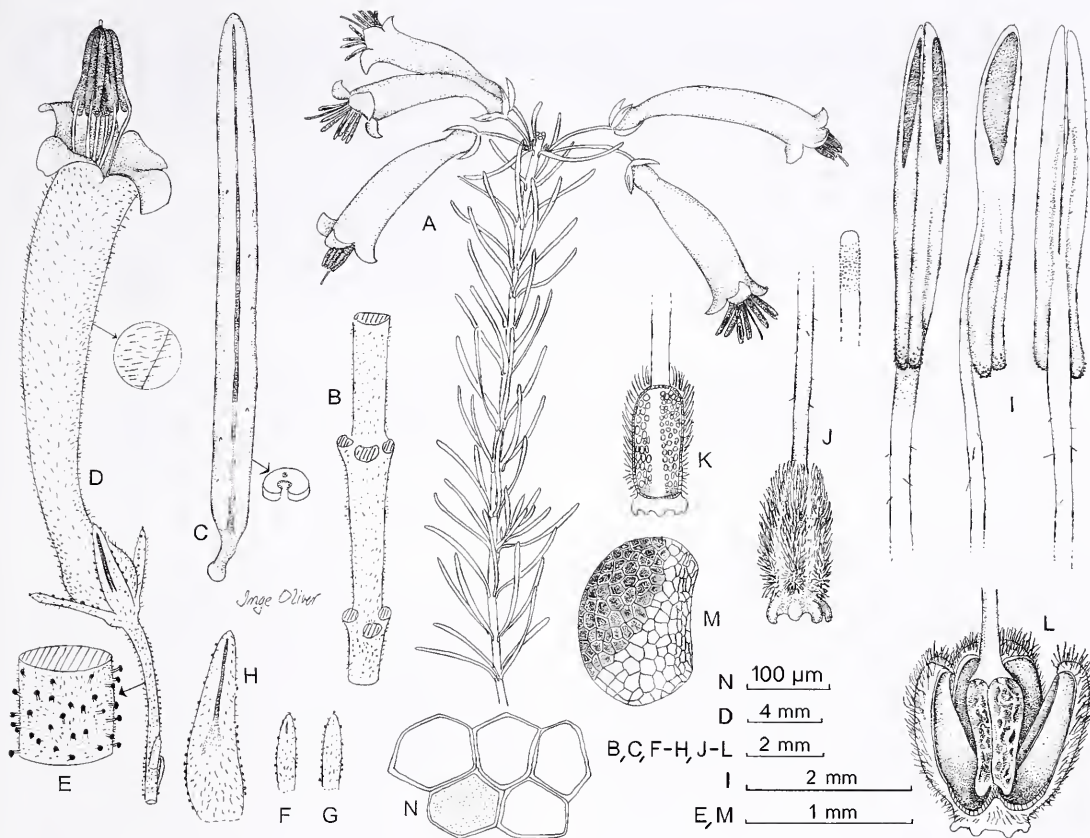


FIGURE 11.—*Erica annalis*. A, flowering branch, natural size; B, stem with leaves removed; C, leaf; D, flower; E, pedicel enlargement; F, bract; G, bracteole; H, sepal; I, anther, front, side and back views; J, gynoecium; K, ovary, opened laterally; L, capsule, with one valve removed; M, seed; N, testa cells. All drawn from the type collection, Oliver & Oliver 11929. Scale bars: B, C, F-H, J-L, 2 mm; D, 4 mm; E, M, 1 mm; N, 100 µm.

walls thin straight inner periclinal wall with numerous small pits. *Flowering time*: July to October, but probably at other times depending on summer rains as evidenced by old flowers on flowering material. Figure 11.

**Diagnostic features:** leaves 4-nate; corolla hairy with a distinct swelling at the base; bract and bracteoles small, remote; anthers well exerted, muticous, long and narrow; sparse hairs on filaments and style; pedicel relatively long, 10–15 mm, with small, sticky, red glands; ovary densely hairy, cylindrical; leaves with very few sclereids.

*E. annalis* could be related to several long-tubed species that occur in the region—*E. wendlandiana* Klotzsch, *E. densifolia* Willd. and *E. abelii* E.G.H.Oliv. and to a lesser extent *E. maximilianii* Bolus. The first three species have the narrow, elongated anthers which are included to slightly manifest, but these are appendiculate, they have the narrow cylindrical ovary but all of them are glabrous, and the hairy corolla. *E. wendlandiana* has the hairy filaments and style which can be present in *E. densifolia* but these are lacking in *E. abelii*. *E. abelii* differs in having a long bract and bracteoles which are approximate to the calyx, not small and remote. All three species differ from *E. annalis* in having 3-nate leaves and no similar basal swelling of the corolla. *E. densifolia* has spike-like synflorescences on

the main stems. *E. wendlandiana* is remarkable in the genus for the large swelling at the base of the style and *E. maximilianii* differs in having a glabrous corolla and a glabrous, broadly obovoid ovary.

This new species is known only from the type locality where it was found during a survey of water catchments in the Kammanassie Mountains by a local Nature Conservation officer, Jan de Jaar. The plants are confined to rock faces, either facing south or north in a single side kloof running east-west. They grow in crevices in the quartzitic rock. On the hot, dry, north-facing cliffs they are the only *Erica* species present but on the cooler, south-facing slopes they grow on steep sheet-rock with small plants of *E. viridiflora* subsp. *primulina*, which is widespread in similar situations in the surrounding mountains (Oliver & Oliver 2002). The surrounding vegetation is arid scrub with no elements of fynbos, which only starts appearing  $\pm$  300 m higher up the slopes.

The epithet for this new species honours the discoverer, the Nature Conservation field officer, Jan de Jaar. We have used the word, *jaar* = year (Afrikaans), *annalis* = relating to a year (Latin), even though his name is probably derived from De Jager, the hunter (Afrikaans/Dutch).

*Paratype material*

WESTERN CAPE—3322 (Oudtshoorn): Uniondale, Buffelsklip, in side kloof next to Buffelskliprivier, 775 m. (–DB), 30-08-2000, *De Jaar 508* (NBG).

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## Studies in the liverwort family Aneuraceae (Metzgeriales) from southern Africa. 4. *Riccardia obtusa*

S.M. PEROLD\*

**Keywords:** Aneuraceae, *Riccardia* Gray, *R. obtusa* S.W.Arnell, southern Africa

### ABSTRACT

For a clearer understanding of *Riccardia obtusa* S.W.Arnell, it is here described and illustrated in greater detail than in Arnell's (1952) initial publication of his new species. Subsequently, with minor alterations, Arnell (1963) repeated his treatment of *R. obtusa* in *Hepaticae of South Africa*. Wigginton & Grolle (1996) have, however, remarked that this species needs to be clarified, along with the other two Arnellian species of *Riccardia*, namely *R. capensis* and *R. rhodesiae*, which will be treated in detail in future papers.

### INTRODUCTION

*Riccardia obtusa* S.W.Arnell appears to be quite widespread in southern Africa, ranging from Karkloof in KwaZulu-Natal to Joubertina in Eastern Cape and Knysna in Western Cape, according to Arnell (1963). The specimen from Pretoria that Arnell (1963) mentioned, had been identified earlier by Sim as *R. compacta*, which is not correct either, as the thalli are much too thin. According to my own observations, *R. obtusa* is also known from Long Tom Pass and Buffelskloof Nature Reserve, Mpumalanga, as well as Kirstenbosch, Cape Town. Samples of fresh collections of it from Fern Forest, Diepwalle (Figure 1), taken in October 2000, were kept alive for as long as 17 months, in order to observe the branching pattern of the thalli, as well as the oil bodies (see Specimens examined). Although Arnell did not remark upon the oil bodies of *R. obtusa*, they are quite distinctive in being very dark and irregular in shape. By the time Arnell described his new species, the oil bodies must have already disappeared.

***Riccardia obtusa* S.W.Arnell** in Botaniska Notiser 1952: 142; S.W.Arnell: 96 (1963). Type: Cape Province, Knysna, Deepwall (= Diepwalle) Forest Reserve, on a wet sandstone slope, *Arnell 1602* (BOL, holo.!: S!).

Thalli prostrate, in densely overlying patches, 2–4 layers thick and tightly adherent to substrate, as well as to each other, often highly contorted and difficult to separate, bottle green and rather brittle; apices of distal branches thickened and fleshy, variously shallowly lobed, margins opaque and obtuse (Figure 2A, B); primary and secondary branches with winged and translucent margins (Figure 2A, C, D); when dry, dark green to brown; smallish to medium-sized. *Main axis* mostly 10–15 mm long, rarely longer, clearly differentiated, distally trifurcate to subpalmately divided, the closely adjoining or overlapping branches lobulate and short, 500–1550  $\mu\text{m}$  wide, their combined width across up to 4.9 mm, apically each branch once, or 2 or 3 times shallowly

notched, with continued growth elongating and becoming fan-shaped and thinner; proximally, main axis generally retaining its dominance, dorsally convex, up to 900  $\mu\text{m}$  wide, narrowing somewhat toward base, branching somewhat irregularly pinnate on both sides, rarely with a much elongated side branch up to 8.5 mm long, similarly branched and in all probability, eventually forming a new main axis. *Primary branches/pinnae* opposite or subopposite, single, 350–2375  $\mu\text{m}$  long, up to 525  $\mu\text{m}$  wide, obliquely spreading at angles of 40°–70° with the main axis and separated by intervals of 825–2300  $\mu\text{m}$  between them; sometimes with only 1 weaker, rarely with 2 (1 on each side) secondary branches/pinnules, so that occasional trifurcate lateral branches arise. *Stolons* (Figure 2C) quite rare, developing laterally from upper or lower part of main axis, or from tip of primary pinna, seldom branched. *Dorsal epidermal cells* in median part of apical segment of main axis from above, 5–7-sided (Figure 2E), cell walls somewhat thickened, 45.0–60.0(–87.5)  $\times$  25.0–32.5(–37.5)  $\mu\text{m}$ , subdorsal cells larger, 112.5–212.5  $\times$  50–85  $\mu\text{m}$ , subventral cells 105–200  $\times$  52.5–77.5  $\mu\text{m}$ , ventral epidermal cells 50–75  $\times$  25–40  $\mu\text{m}$ . *Oil bodies* very densely crowded at meristematic apical notches of branches and then present in up to 90% of dorsal and ventral epidermal cells, as

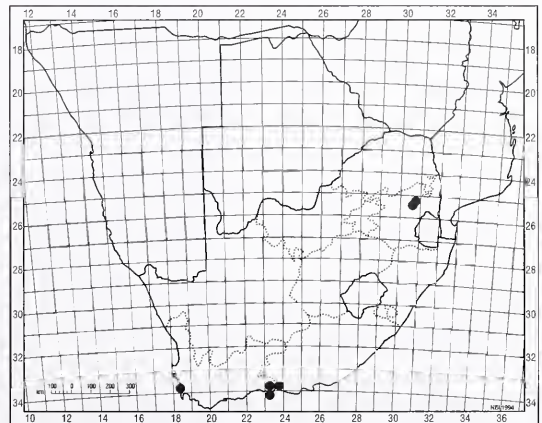


FIGURE 1.—Distribution of *Riccardia obtusa* in southern Africa.

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MS. received: 2002-06-27.



FIGURE 2.—*Riccardia obtusa*. A–C, thallus; A, with subpalmate distal branching and irregularly pinnate lateral branching; B, with several gynoecial branches; C, with single male branch and a stolon. D, primary branch. E, median dorsal epidermal cells (solid lines) of ultimate segment of axis with smaller oil bodies, and large subdorsal cells (stippled lines) with larger oil bodies (oil globules indicated by stippling); F, marginal cells of ultimate segment of axis, oil bodies stippled; G, H, c/s axis at  $\pm$  middle of ultimate segment; I–K, c/s primary branches; L, c/s stolon; M, mucilage papillae at ventral apical notch of branch; N<sub>1</sub>, N<sub>2</sub>, gemmae. O–Q, antheridial branch: O, from above; P, from side; Q, c/s. R, gynoecial branch from side; S, calyptra; T, c/s calyptra wall; U, c/s seta; V, c/s part of bistratose wall of capsule valve showing different cell walls: abr, abaxial radial; adr, adaxial radial; it, inner tangential; mw, median; ot, outer tangential. W<sub>1</sub>, W<sub>2</sub>, spores; X, elater. A, B, L, N–Q, S, Perold & Koekemoer 4456; C, F, H–K, R, T, V–X, Perold & Koekemoer 4457; D, Koekemoer 2246; E, Perold, Burgoyne & Smithies 4743; G, M, Perold & Koekemoer 4462; U, Perold & Koekemoer 4460.



well as in marginal and internal cells, mostly 1, but occasionally 2 or 3 per cell, smaller in dorsal and ventral epidermal cells,  $12.5\text{--}20.0 \times 12.5\text{--}17.5\text{ }\mu\text{m}$ , larger in internal cells,  $25.0\text{--}32.5 \times 15.0\text{--}27.5\text{ }\mu\text{m}$ , irregular or kidney-shaped, occasionally subspherical, very dark, composed of many tiny globules. *Margins* of ultimate segments of main axis (Figure 2F) with outer cells generally somewhat smaller than intramarginal ones, from above  $42.5\text{--}57.5 \times 27.5\text{--}47.5\text{ }\mu\text{m}$ , rectangular to subquadrate, free walls bulging slightly outward, most cells with a single oil body,  $12.5\text{--}20.0 \times 10\text{--}20\text{ }\mu\text{m}$ ; intramarginal cells 5- or 6-sided,  $57.5\text{--}100.0 \times 35.0\text{--}62.5\text{ }\mu\text{m}$ , with 1, occasionally 2 oil bodies each. *Cross section* at  $\pm$  middle of ultimate segment of main axis biconvex (Figure 2G, H),  $840\text{--}1040\text{ }\mu\text{m}$  wide and  $5\text{--}8\text{--}(11)$  cell rows or up to  $325\text{ }\mu\text{m}$  thick medianly, gradually tapering to obtuse margins, thickness of dorsal cells  $12.5\text{--}15.0\text{ }\mu\text{m}$ , subdorsal cells  $25\text{--}30\text{ }\mu\text{m}$ , medullary cells  $(40\text{--})60\text{--}100\text{ }\mu\text{m}$ , subventral cells  $\pm 30\text{ }\mu\text{m}$  and ventral cells  $\pm 15\text{ }\mu\text{m}$ ; base of main axis generally narrower than younger part further along,  $\pm 680\text{ }\mu\text{m}$  wide, 6 cell rows or  $\pm 200\text{ }\mu\text{m}$  thick, margins shortly acute; cross section of primary branch/pinna (Figure 2I–K)  $85\text{--}110\text{ }\mu\text{m}$  or 3 or 4 cell layers thick medianly, unistratose margins 3 or 4 cells wide; cross section of secondary branch/pinnule  $\pm 55\text{ }\mu\text{m}$  or 3 cell layers thick; cross section of stolons (Figure 2L), oval to elliptical,  $\pm 140 \times 210\text{ }\mu\text{m}$ . *Mucilage papillae* (Figure 2M) ventral, crowded together at shallowly notched apex of branch and then in 2 spaced rows, one on either side of midline,  $150\text{--}225\text{ }\mu\text{m}$  between successive ones, club-shaped,  $50\text{--}80\text{ }\mu\text{m}$  long,  $17.5\text{--}37.5\text{ }\mu\text{m}$  wide above, tapering to foot,  $10.0\text{--}12.5\text{ }\mu\text{m}$  wide. *Rhizoids* ventral along branches,  $10.0\text{--}12.5\text{ }\mu\text{m}$  wide. *Asexual reproduction* by gemmae (Figure 2N) occasionally observed on dorsal surface of upper branches, consisting of 2 cells joined together,  $\pm 65 \times 40\text{ }\mu\text{m}$ .

Monoicous. *Antheridial branches* rather few in number, arising laterally on main axis (Figure 2C), immediate-

ly below base of primary branch or subopposite to base of primary branch, sometimes 2 together, sometimes shortly stipitate, oblong-linear,  $1125\text{--}1300\text{ }\mu\text{m}$  long, width  $250\text{--}270\text{ }\mu\text{m}$ , in cross section  $\pm 240\text{ }\mu\text{m}$  high, bearing up to 11 pairs of antheridia, on same plant occasionally shorter male branches,  $460\text{--}830\text{ }\mu\text{m}$  long, width up to  $220\text{ }\mu\text{m}$ , with 4–9 pairs of antheridia, antheridial cavities from above  $50.0\text{--}62.5 \times 32.5\text{--}47.5\text{ }\mu\text{m}$ , surrounding cells  $37.5\text{--}42.5 \times \pm 30\text{ }\mu\text{m}$ , 1 or 2 adjoining cells between pairs of cavities; margins (Figure 2O) crenulate, with single erect layer of swollen cells,  $65.0\text{--}87.5 \times 45\text{--}65\text{ }\mu\text{m}$ . *Gynoeceial branches* (Figure 2R) short, arising laterally on same side along length of main axis, 2 or 3 in a row, sometimes in pairs on opposite sides of primary branch,  $\pm 260\text{ }\mu\text{m}$  high,  $450\text{ }\mu\text{m}$  wide, surrounding paraphyses up to  $310\text{ }\mu\text{m}$  long, composed of 3 or 4 cells joined end to end, archegonia in 2 rows. *Calyptra* (Figure 2S) clavate, length  $2.0\text{--}3.5\text{ mm}$ ,  $\pm 0.85\text{ mm}$  wide above and narrowing below to  $\pm 0.6\text{ mm}$ ; cross section of wall (Figure 2T)  $170\text{--}200\text{ }\mu\text{m}$  or up to 8 cell layers thick, many cells of outermost row markedly protuberant,  $115\text{--}135 \times \pm 25\text{ }\mu\text{m}$ , cells in corona up to  $175\text{ }\mu\text{m}$  long. *Seta*  $\pm 5.7\text{ mm}$  long,  $220\text{--}280\text{ }\mu\text{m}$  wide, with 4 inner and 12 outer cell rows, i.e. 4 cells diam. (Figure 2U). *Capsule* ellipsoidal,  $1150\text{--}1675\text{ }\mu\text{m}$  long, with 4 valves,  $\pm 325\text{ }\mu\text{m}$  or  $21\text{--}23$  cell rows wide, bistratose; cells of epidermal layer in external longitudinal view (Figure 3A)  $67.5\text{--}90.0 \times 10.0\text{--}12.5\text{ }\mu\text{m}$ , end walls straight or oblique, with vertical (nodular) thickenings; in cross section (Figure 2V) cells rectangular in shape, thickenings on adaxial radial and inner tangential walls, bands on one side of median wall alternating in a mirror image with those on the other side; inner cells in internal longitudinal view,  $65\text{--}90 \times 10.0 \times 17.5\text{ }\mu\text{m}$ , without nodular thickenings (Figure 3B); in cross section (Figure 2V) cells faintly thickened on adaxial radial walls. *Spores*  $12.5\text{--}15.0\text{ }\mu\text{m}$  diam., finely scabrate, pink with internal green areas. *Elaters*  $115\text{--}340 \times \pm 12.5\text{ }\mu\text{m}$ , reddish, with single spiral band,  $7.5\text{--}10.0\text{ }\mu\text{m}$  wide, the tapered tips at one or both ends without spirals.

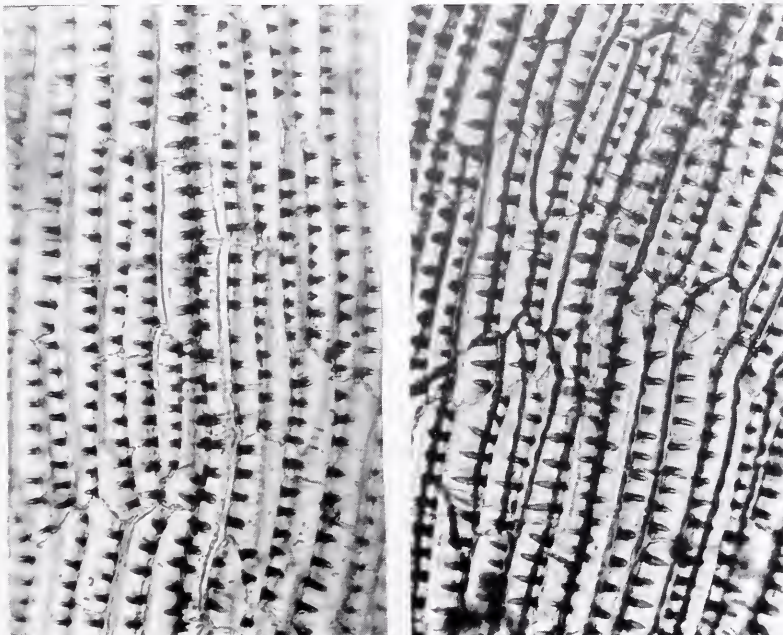


FIGURE 3.—*Riccardia obtusa*. A, cells of epidermal layer of wall of valve in external longitudinal view,  $\times 389$ . B, cells of inner layer of wall of valve in internal longitudinal view,  $\times 389$ . A, B, Perold & Koekoemoer 4456.

## DISCUSSION

In his paper on the genus *Riccardia* in tropical Africa, Jones (1956) remarked that he had not seen specimens 'of *R. campanuliflora* S.Arnell, *R. capensis* S.Arnell or *R. rhodesiae* S.Arnell (*Botaniska Notiser* 1952)', but he made no reference to *R. obtusa* S.W.Arnell, which was published in the same paper as Arnell's other three new species. Later on, Engel (1975) identified a specimen collected on Réunion as *Riccardia* cf. *obtusa* S.Arnell, but added a question mark as follows: 'Wet woods, Forêt de Bebour, 1300 m (?), 10118g' (collecting number of Harold E. Moore). It would appear that this altitude is questionable.

Grolle (1995) refers to the above in his publication, *The Hepaticae and Anthocerotae of the East African Islands. An annotated catalogue*, excluding it from Réunion. In Wigginton & Grolle (1996) it is observed that *R. obtusa* needs to be clarified.

Bearing in mind Meenks' (1987) admonition that herbarium collections of *Riccardia* more than 20 years old, are often useless, Arnell's identification of three collections of *R. obtusa* specimens is accepted, because he had the advantage of studying them when fresh. According to Arnell, this species resembles *R. latifrons*, in that it has short, blunt branches. Schuster (1992) described *R. latifrons* as closely adherent to the substrate and subpalmately branched distally; the epidermal cells of the thalli are, however, typically very large, always thin-walled with colourless walls and the oil bodies are absent near the meristematic tips and in all the epidermal cells. It is also confined to the Northern Hemisphere. There are, therefore, significant differences between these two species.

*R. obtusa* specimens are distinguished by the following characters: 1, the obtuse margins (hence the specific name) of the distal branches; 2, the distal trifurcate to subpalmate branching pattern; 3, the closely adjoining or overlapping, lobulate apical branches; 4, the markedly thickened ultimate segments of the main axes, 5–8(–11) cell rows thick; 5, the primary and secondary branches with unistratose margins; 6, the prominent cell protrusions on the calyptra wall; 7, the distinct oil bodies, which are very dark and irregular to kidney-shaped or subspherical.

## SPECIMENS EXAMINED

*Arnell 1602* (holotype), Deepwall (= Diepwalle) Forest Reserve, on a wet sandstone slope (BOL), (isotype) (S), 1620 Deepwall Forest, wet slope (S), 1628, near Parkes Station, Knysna, wet sandstone slope (BOL).

*Esterhuysen 24255*, N side of Zitzikamma Mts, near Joubertina, wet shaded rock at side of stream on steep slope (BOL).

*Koekemoer 2246*, Buffelskloof Nature Reserve, south of Lydenburg, in stream south of Research Cottage, on roots and stem of tree fern (PRE).

*Perold, Burgoyne & Smithies 4742, 4743*, Long Tom Pass, near 'Staircase', ± 25 km from Lydenburg, in gully down steep slope (PRE).

*Perold & Koekemoer 4456, 4457, 4460, 4462*, Valley of Ferns, on rotting logs, soil or stone along footpaths, 4592, Kirstenbosch, in dark gorge above ladders (PRE).

*Schelphe 5154*, 'Braco', Karkloof, Natal, on fallen logs in forest (BOL).

## ACKNOWLEDGEMENTS

The curators of BOL, G and S are thanked for the loan of specimens. I also express my sincere gratitude to Dr M. Koekemoer, curator of PRE, and to the ladies P. Burgoyne & S. Smithies, for all their assistance with fieldwork, as well as to the referees for their helpful suggestions and advice. The artist, Ms G. Condry, the photographer, Mrs A. Romanowski and the typist, Ms D. Maree are thanked for their valued contributions.

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# Notes on African plants

## ASTERACEAE–ANTHEMIDEAE

### REDUCTION OF *FOVEOLINA ALBIDA* TO *FOVEOLINA DICHOTOMA*

In the past it has been difficult to distinguish between *Foveolina albida* (DC.) Källersjö and *F. dichotoma* (DC.) Källersjö, resulting in a rather confused collection of herbarium specimens. These two species were considered species of *Matricaria* by Harvey in *Flora capensis* (1865). Harvey (1865) regards *Matricaria dichotoma* (DC.) Fenzl ex Harv. to be near *M. albida* (DC.) Fenzl ex Harv., but the leaves are less compound. In *M. dichotoma* the leaves are simple pinnatisect, the lobes flat and linear, whereas in *M. albida* the leaves are bipinnatisect, and the lobes and lobules narrow. Källersjö (1988) distinguishes between the two species on the shape of the corolla of the disc florets. In *F. dichotoma*, the corolla limb is broadly campanulate and the tube conspicuously dilated at the base. In *F. albida* on the other hand, the limb is not broadly campanulate and the tube is almost cylindrical. After careful scrutiny of all the specimens of these two species in NBG, no distinct difference between the two species could be found. Sometimes in a single specimen both simple pinnatisect and bipinnatisect leaves occur. Similarly the limb of the corolla can be broadly to narrowly campanulate and the tube may vary from almost cylindrical to dilated at the base within one specimen. In the distinguishing characters of Harvey (1865) and Källersjö (1988) there is a gradation from the one form to the other. Since these two species are conspecific, *F. albida* is placed into synonymy under *F. dichotoma*. Both species were described in the same publication under the different genera (De Candolle 1838). Since *F. dichotoma* is the type species of the genus (Källersjö 1988), it is therefore chosen here to represent the species.

**Foveolina dichotoma** (DC.) Källersjö in Botanical Journal of the Linnean Society 96: 319 (1988). *Pentzia dichotoma* DC.: 138 (1838). *Matricaria dichotoma* (DC.) Fenzl ex Harv.: 167 (1865). Type: ad Caput Bonae Spei prope Olifantsrivier, Drège s.n. (G-DC, holo.; K!, S).

*Tanacetum albidum* DC.: 132 (1838). *Matricaria albida* (DC.) Fenzl ex Harv.: 166 (1865). *Pentzia albida* (DC.) Hutch.: 250 (1917). *Foveolina albida* (DC.) Källersjö: 319 (1988). Type: ad Caput Bonae Spei in Klein Namaqualand, Drège s.n. (G-DC, holo.–PRE, microfiche!).

*Pentzia annua* DC.: 138 (1838). Type: ad Caput Bonae Spei in regione Gariepina, Drège s.n. (G-DC, holo.–PRE, microfiche!).

*Matricaria hirsutifolia* S.Moore: 1019 (1904). Type: Gross-Namaland, Dinter 1221 (not seen).

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## ASTERACEAE

### A NEW SPECIES OF *ARCTOTHECA* FROM NORTHERN CAPE, SOUTH AFRICA

**Arctotheca marginata** Beyers, sp. nov., habitu *A. prostratae* (Salisb.) Britten similis sed foliis lineari-ellipticis vel lineari-obovatis, adaxiale tomentosus, abaxiale coactis, margine erosa revoluta distincte aculeato, involucri abaxiale coacto, pappo flosculorum discorum squamis 7–10 hyalinis differt.

TYPE.—Northern Cape, 3119 (Calvinia): Nieuwoudtville, Farm Grootvlei, along edge of pan, ± 760 m. (–AC), 23-11-2001, *Bosenberg 1* (NBG, holo.; BOL, K, MO, PRE).

Perennial, tufted, stoloniferous herb. *Stem* prostrate, rooting at nodes. *Leaves* alternate, petiolate; blade linear-elliptic or linear-obovate in outline, 35–75 × 3–10 mm, adaxially tomentose, abaxially felted, margin erose, revolute and distantly aculeate; petiole 25–70 × 2–3 mm, up to 7 mm wide at base, felted. *Capitula* heterogamous, radiate,

solitary on long peduncles; peduncles 40–80 mm long, felted. *Involucre* widely cup-shaped, 10–13 mm diam. *Involucral bracts* 5- or 6-seriate, imbricate; outer narrowly ovate or narrowly oblong with acute apex, 2.8–4.7 × 0.9–1.0 mm, coriaceous, abaxially felted; inner gradually larger, narrowly elliptic to elliptic with acute apex, coriaceous, abaxially felted; innermost elliptic to obovate, 6–9 × 2.2–2.3 mm, with broad scarious margin, central coriaceous portion abaxially tomentose, apex rounded to obtuse. *Receptacle* flat, honeycombed, fimbriiferous. *Ray florets* neuter, 13 or 14; tube cylindrical, 2.0–2.4 mm long; lamina spreading, narrowly elliptic, 8.7–9.2 × 1.7–2.0 mm, yellow above, reddish brown below, 4-veined, apically minutely 3-lobed; vestigial staminodes 2–4; ovary with aborted style; pappus absent. *Disc florets* bisexual, numerous; corolla yellow, narrowly cyathiform tapering into tube below, 3.4–4.4 × 1.0–1.2 mm; corolla lobes 5, ascending,

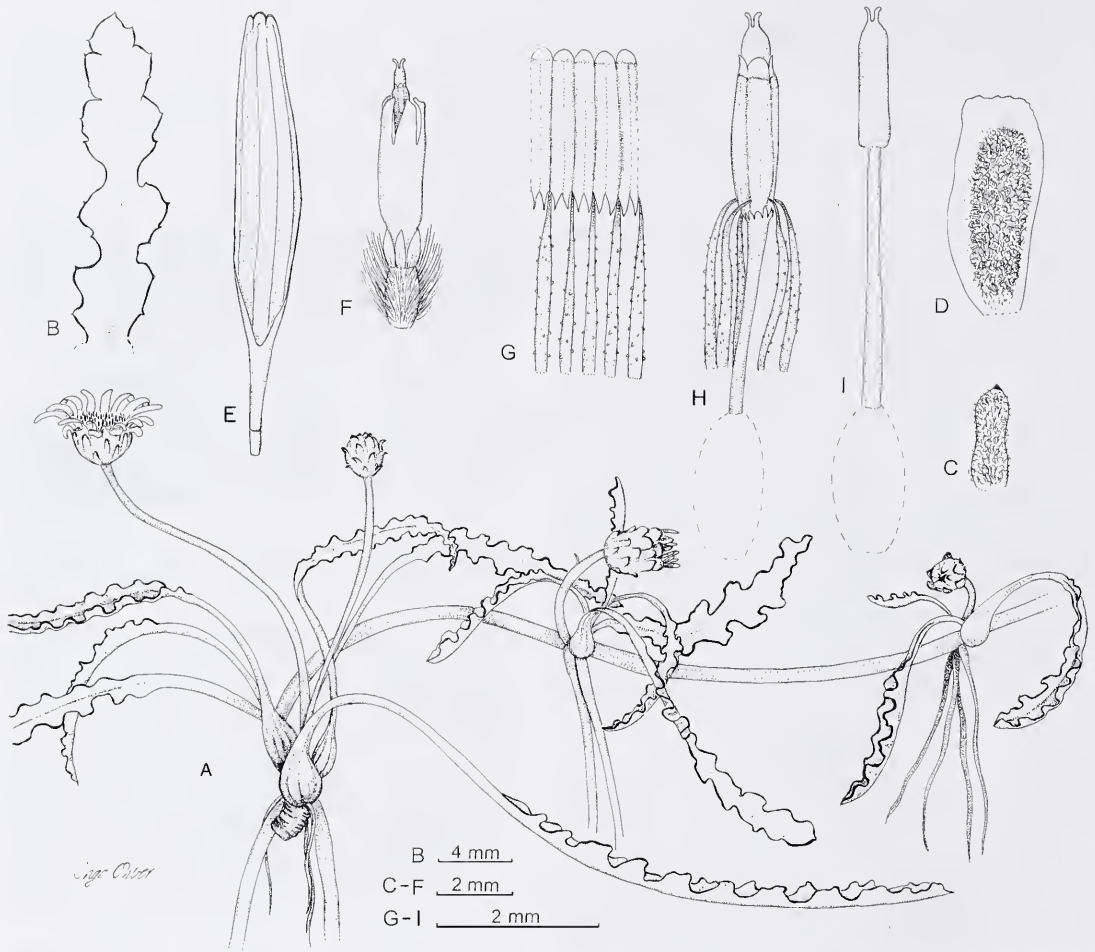


FIGURE 1.—*Arctotheca marginata*, Bosenberg 1 (NBG). A, portion of a plant,  $\times 1$ ; B, portion of leaf blade; C & D, involucral bracts (abaxial view): C, outer; D, innermost. E, ray floret. F–I, disc floret: G, stamens; H, stamen and style; I, style. Scale bars: B, 4 mm; C–F, 2 mm; G–I, 2 mm. Artist: Inge Oliver.

ovate-triangular, up to  $1.3 \times 0.5$ – $0.8$  mm; stamens 5; anthers 2.0–2.2 mm long, linear, with sterile flat, depressed-ovate apical appendage, base triangular; filament scabrous; style 4.9–5.7 mm long, terete, thickened above, bifid, style branches up to 0.2 mm long; cypsela narrowly ellipsoid, 1.5–1.7 mm long, densely pilose, hairs tending to cohere; pappus scales hyaline, 7–10, narrowly elliptic,  $1.0$ – $1.3 \times 0.3$ – $0.5$  mm, apex acute. Figure 1.

**Diagnostic characters:** *Arctotheca marginata* is morphologically rather close to *A. prostrata* due to the stoloniferous growth, but is distinguished from it by the leaves which are linear-elliptic or linear-obovate in outline with an erose, revolute and distantly aculeate margin, tomentose above and felted beneath, and the involucre which is abaxially felted. In *A. prostrata* the leaves are lyrate-pinnatifid, green above, white-woolly beneath, the involucre is glabrous or thinly tomentose with white-woolly apices and the pappus is absent.

**Distribution and ecology:** *Arctotheca marginata* is known only from the Farm Grootvlei in Nieuwoudtville. It occurs in deep, waterlogged, sandy soil along the edge of a pan. Figure 2.

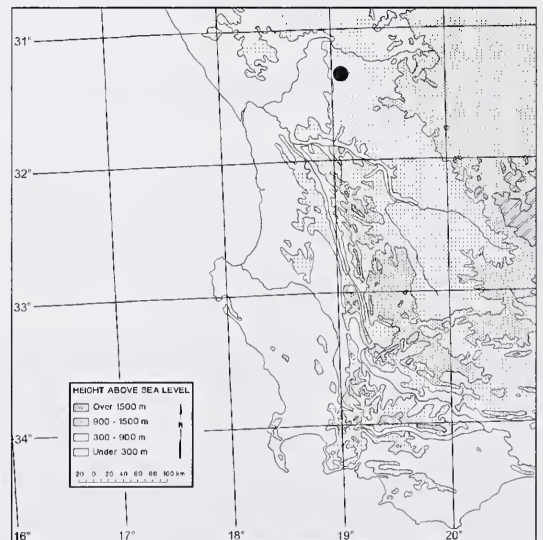


FIGURE 2.—Geographical distribution of *Arctotheca marginata*.



*Etymology:* the specific epithet, *marginata*, meaning edge, was prompted by this species growing on the edge of the pan.

#### *Other specimen examined*

NORTHERN CAPE.—3119 (Calvinia): Nieuwoudtville, Farm Grootvlei, along edge of pan,  $\pm$  760 m. (–AC), 7-11-2001, Roux 3168 (NBG).

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## MESEMBRYANTHEMACEAE

### MESEMBS WITH NUT-LIKE SCHIZOCARPIC FRUIT AND *RUSCHIANTHEMUM* FRIEDRICH SUNK UNDER *STOEBERIA* DINTER & SCHWANTES

#### INTRODUCTION

Fruit of most Mesembryanthemaceae are hygrochastic: they open, disperse seed and close again in response to moisture. This moisture-mediated mode of seed dispersal is achieved through a sophisticated mechanism based on the hygroscopic properties of expanding keels that function to open and close the valves or lids of loculicidal capsules (Hartmann 1988; Croizat 1993). In the more complex hygrochastic fruit, the amount of seed dispersed and their trajectories, are controlled through various structures such as covering membranes and closing bodies (Parolin 2001). However, modes of dispersal in Mesembryanthemaceae vary widely depending on the construction of the fruit. The genus *Carpobrotus* N.E.Br., for example, has edible berry-like fleshy fruit (sour fig), with seeds embedded in thick, sticky mucilage. A few genera possess xerochastic fruit that dehisce when dry.

#### XEROCHASTIC FRUIT

Mesemb genera with fruit which open when dry are found mostly in the tribe Apatesieae emend. Chesselet, G.F.Sm. & A.E.van Wyk (Chesselet *et al.* 2001). Species of *Conicosia* N.E.Br., for example, have capsules which function as shakers, in a way similar to that of poppies. In addition to having seeds in their locules, the fruit of *Conicosia* and *Skatophytum* L.Bolus have seed chambers or pockets, the 'Samentaschen' of Schwantes (1949, 1957), in which a few seeds are entombed in woody tissue. A few genera possess schizocarpic fruit which break up into mericarps when dry. The terms schizocarp and mericarp are not used in their strictest sense here, because the mericarps of mesemb are formed by two halves of neighbouring carpels (Leistner 1958). The genus *Hymenogyne* Haw. has schizocarpic fruit which break up into 8–12 one-seeded, flat, broadly winged, circular mericarps. Seeing that the fruit of certain species of *Conicosia* may disintegrate in a comparable way, Schwantes (1927) erected the genus *Herrea* which is no longer considered distinct. The retention of seeds in seed pockets outside the locules was mentioned above for *Conicosia* and *Skatophytum*. Among the Apatesieae this syndrome has reached its highest degree of development in *Caryotophora skatophytoides* Leistner (Figure 3G, H). Its fruit is a schizocarp which breaks up into 3 or 4

nut-like mericarps. Two genera outside the Apatesieae also encompass species with seed enclosed in hard, woody, nut-like mericarps: *Brownanthus* and *Ruschianthemum*.

#### EVOLUTION OF NUT-LIKE MERICARPS

The evolutionary development of nut-like fruit from hygrochastic capsules may be regarded as a convergent adaptive feature, since this has occurred more than once in the evolution of the Mesembryanthemaceae, with *Ruschianthemum gigas* (Dinter) Friedrich as an example from subfamily Ruschioideae (Figure 3A–D), and *Pseudobrownanthus micifer* Ihlenf. & Bittrich from subfamily Mesembryanthemoideae (Figure 3E, F). We speculate that in these two species, the evolution of nuts may be a seed-protecting mechanism that has evolved under the extreme arid conditions that these species experience, both taxa being restricted to southern Namibia and the Richtersveld, South Africa. From a structural perspective, Hartmann (1988) ascribes the evolutionary derivation of nuts or nutlets in the mesemb to a process of increased sclerenchymatization of all tissues in the fruit. This phenomenon is supposedly associated with the evolutionary replacement of raindrops by wind as the prime dispersal agent in species exhibiting these characteristics (Hartmann 1988, 2001). However, diaspores are not accompanied by wings or plumes and the evolutionary change to nutlets may rather be an adaptation to larger seed size which may confer a competitive advantage to the seedlings, especially in areas with unpredictable follow-up rains. In *Caryotophora skatophytoides* Leistner (Figure 3G, H) and in *Skatophytum tripolium* (L.) L.Bolus (Figure 3I), the selective pressures are different from those acting in the arid parts of Namibia and South Africa. Both species occur in the fynbos vegetation of Western Cape, South Africa, with *C. skatophytoides* from near Bredasdorp and *S. tripolium* from the Cape Peninsula and surrounding areas. Ecological factors that characterize this Mediterranean climate region include summer aridity, mineral-poor soils, wind and fire. *C. skatophytoides* is only found in post-fire vegetation. This perennial plant is known to resprout from suckers following fire, whereas the annual *S. tripolium* reseeds after fire. In both cases seeds germinate with difficulty (Hickey & Van Jaarsveld 1995) and the nut-like fruit of

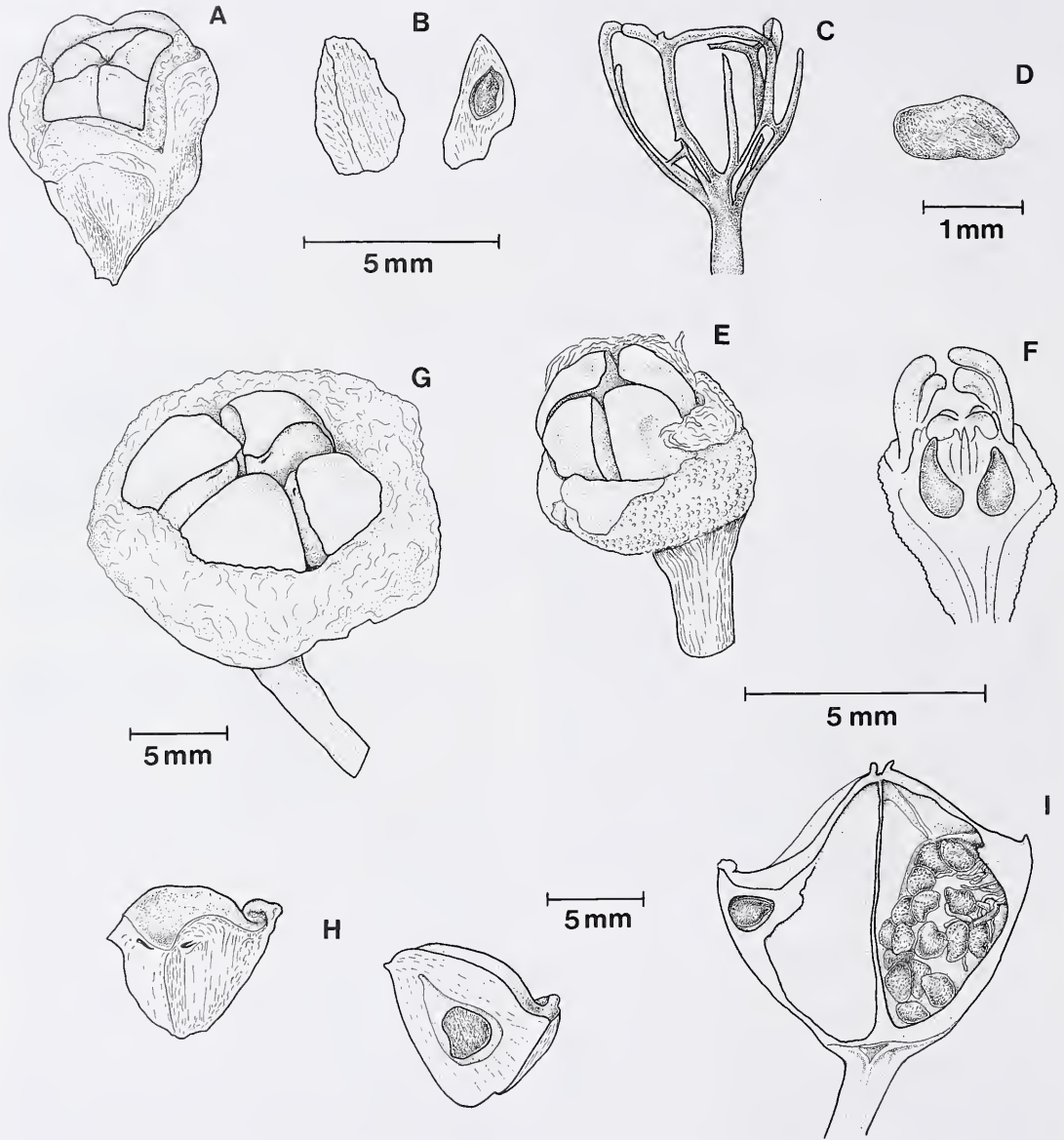


FIGURE 3.—Mesembs with nut-like schizocarpic fruit. A–D, *Stoeberia gigas*; E, F, *Brownaanthus uucifer*; G, H, *Caryotophora skiatophytoides*; I, *Skiatophytum tripolium*. Scale bars: A–C, E–I, 5 mm; D, 1 mm. Artist: P. Chesselet.

*C. skiatophytoides* decay slowly in habitat. Hickey & Van Jaarsveld (1995) suggest that delayed seed germination is a survival strategy commonly found in fynbos plants.

#### BROWNANTHUS, RUSCHIANTHEMUM AND STOEBERIA

The unusual nut-like fruit of *Ruschianthemum gigas* and of *Pseudobrownaanthus uucifer* were thought to be sufficient reason to establish the monotypic genera *Ruschianthemum* and *Pseudobrownaanthus* (Friedrich 1960; Ihlenfeldt & Bittrich 1985). The widely accepted importance of fruit structure in the taxonomic subdivision of the family provided justification for these gener-

ic separations e.g. Dehn (1992), however, increasingly, fruit types are not regarded as superior characters for generic delimitation and all characters need to be considered (Klak 2001). In a recent study of *Brownaanthus*, Pierce & Gerbault (1997) argued that *P. uucifer* is but a specialized member of *Brownaanthus* which now contains 12 species, including the new combination *Brownaanthus uucifer* (Ihlenf. & Bittrich) S.M.Pierce & Gerbault. This taxonomic decision is supported by molecular data, and *Pseudobrownaanthus* is deeply embedded within *Brownaanthus* (C. Klak, BOL, University of Cape Town, pers. comm.), suggesting that the nut-like fruit represents an autapomorphy for the species rather than a character providing resolution at genus level. The relative importance assigned to a character set, such as fruit structure,



and especially its relevance at a particular rank in the taxonomic hierarchy, needs to be carefully considered when establishing new genera based on autapomorphies. In an analysis of the genera of the Mesembryanthemaceae, Chesselet *et al.* (1995) showed a high number of monotypic genera in this family. Many taxonomists have misgivings about very large genera and genera with only one species, yet both are integral to classification schemes (Williams 1964). But, some monotypic genera are founded on peculiarities, and under such circumstances genus and species concepts may converge, as in the case of *Pseudobrownanthus*. In this paper, we use similar argumentation to resurrect *Stoeberia gigas* (Dinter) Dinter & Schwantes.

The type of *Ruschianthemum gigas* (Dinter) Friedrich was collected in the Klinghardt Mountains of southern Namibia in September 1922 by Moritz Kurt Dinter, a renowned botanist and botanical explorer of Namibia. Prior to the establishment of *Ruschianthemum*, *Mesembryanthemum gigas* Dinter (Dinter 1923) was placed in the genus *Stoeberia* Dinter & Schwantes emend. Friedrich, emend. Dehn (Schwantes 1927–1928; Friedrich 1960; Dehn 1992), together with *S. beetzii* (Dinter) Dinter & Schwantes and *S. rupis-arcuatae* (Dinter) Dinter & Schwantes, a species that is now classified in the genus *Amphibolia* L.Bolus. *Ruschianthemum* was established by Friedrich (1960) on account of its unusual fruit structure—the mature fruit of *R. gigas* is a five-locular schizocarp which breaks into nutlets consisting of parts of the septum enclosing one seed and the remains of valve wings and expanding keels adhering to each unit. Following the release of the nutlets, persistent dorsal and apical connecting vascular bundles present in the capsule remain on plants as a fibrous, basket-like skeleton (see Smith *et al.* 1998: 363; Burgoyne 2000: 8). Although used as a diagnostic feature of *Ruschianthemum* (Dehn 1992), similar basket-like fruit remains have now also been noted in *Stoeberia frutescens* (L.Bolus) Van Jaarsv. When not in fruit, *R. gigas* may be easily mistaken for a *Stoeberia* which it closely resembles (Van Jaarsveld 1994).

*Ruschianthemum* has been classified together with *Stoeberia*, *Amphibolia* and *Eberlanzia* Schwantes in the 'Eberlanzia Group' by Hartmann (1998). This group shares the following characteristics: stems whitish; capsules with valve wings and closing bodies which are mostly small and often deep inside the locules so that they appear absent. In this group, *Ruschianthemum* is closest to *Stoeberia* (Hartmann 2001), sharing with it the nearly club-shaped leaves and the rich dichasial inflorescences. The flowers of *Ruschianthemum* closely resemble those in the genus *Stoeberia*—they are relatively small and numerous, with pink-tipped filamentous staminodes arranged in a cone; *S. carpii* Friedrich with its large white flowers, is unique in the genus but fruit and vegetative characters support its current placement in *Stoeberia*. Both genera have the lophomorphic holonecary characteristic of genera placed in Tribe Ruschieae Schwantes by Chesselet *et al.* (2001, in press).

In Schwantes' (Schwantes 1927–1928) key to mesemb genera, *Stoeberia* is distinguished from other genera by its capsule with rudimentary covering mem-

branes that are developed as a narrow rim, with valve wings, and very large placental tubercles (closing bodies) and stigmas that are short, dark and feathered. In the present circumscription of *Stoeberia* the valves do not close again completely once they have opened, and hard (sclerified) valve wings and recurved valve rims characterize the fruit (Chesselet *et al.* 2000). If we amend these diagnostic characters to sclerification of fruit tissue in a broader sense, we can accommodate *R. gigas* in *Stoeberia* and reassign this species accordingly.

***Stoeberia gigas* (Dinter) Dinter & Schwantes in Zeitschrift für Sukkulantenkunde 3: 17 (1927).**

*Mesembryanthemum gigas* Dinter in Feddes Repertorium 19: 153 (1923). *Ruschianthemum gigas* (Dinter) Friedrich in Mitteilungen der Botanischen Staatssammlung, München 3: 564 (1960). Type: Namibia, Klinghardt Mountains, September 1922, Dinter 3791 (B!, holo.).

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## HYACINTHACEAE: MASSONIEAE

### A NEW SPECIES OF *LACHENALIA* FROM NAMAQUALAND, SOUTH AFRICA

#### INTRODUCTION

*Lachenalia* Jacq.f. ex Murray is the largest endemic genus within the southern African Hyacinthaceae and comprises ± 117 species. The distribution of the genus is concentrated in the winter rainfall zone of the subcontinent, but also extends into areas of intermediate as well as summer rainfall (Duncan 1998a). All its species follow a strictly winter-growing, summer-dormant life cycle, with the exception of *Lachenalia pearsonii* (Glover) W.F.Barker from southern Namibia, which is summer-growing and winter-dormant (Duncan 1999). The genus is exceptionally diverse in flower shape, colour and orientation, as well as in leaf shape, surface sculpturing and markings, and is cytologically also very varied. *Lachenalia* comprises several very widely distributed species, but a much larger number are confined to narrow distribution ranges, such as the species described here. The genus occurs across a wide variety of habitats and vegetation types, including Succulent Karoo, Nama-Karoo, Fynbos and Grassland Biomes. Many of the species have great ornamental value (Duncan 1988, 1989a, b), and hybrids developed by the Agricultural Research Council at Rooideplaas near Pretoria, have recently been introduced onto the international pot plant market. The new species described here forms part of a series of papers towards a revision of the genus (Duncan 1996, 1997, 1998b).

#### *Lachenalia valeriae* G.D.Duncan, sp. nov.

Planta 100–350 mm alta; bulb subglobosus, 15–20 mm diam., albus, tunicis externis tenuibus brunneis; folia 2, late lanceolata ad anguste ovata, 120–170 × 20–30 mm, patentia, pagina superiore venis longitudinaliter depressis pustulis minutis dense tecta; flores oblongo-urceolati, sessiles, patentes, pallide viridiflavi, tubo perianthii cretneo 2–3 mm longo, tepalis exterioribus ovatis 7–8 × 4–5 mm, tepalis interioribus obovatis, apicibus parum recurvatis, tepalis duobus superioribus imbricatis 9–10 × 5 mm, tepalo inferiore longiore angustioreque 10–11 × 3–4 mm, in parte superiore vivide magenteo; stamina inclusa declinata 7 mm longa.

TYPE.—Northern Cape, 2917 (Springbok): north-western Namaqualand, Kleinsee Nature Reserve, Kleinsee,

on west-facing granite slopes in brownish red sand, (–CA), *Duncan 444* (NBG, holo.).

Deciduous, winter-growing geophyte, 100–350 mm high. *Bulb* subglobose, 15–20 mm diam., usually solitary, occasionally clump-forming; white with thin, membranous, pale to dark brown outer tunics, produced into a very short neck; cataphyll subterranean, translucent white with minute longitudinal veins, loosely clasping leaf base. *Leaves* 2, broadly lanceolate to narrowly ovate, 120–170 × 20–30 mm, spreading or suberect, canaliculate, upper surface dark green with distinct depressed longitudinal veins, densely covered with minute, dark green pustules, lower surface plain or lightly to heavily flushed with maroonish magenta; clasping leaf base 20–50 mm long, yellowish green or heavily flushed with dark maroonish magenta above soil level, shading to white below soil level. *Inflorescence* an erect, many-flowered dense spike up to 120 mm long with short sterile tip; peduncle erect, sturdy, up to 230 mm long, lower half pale green with minute brownish purple speckles, upper half heavily mottled with brownish purple; rachis pale purplish brown in lower half, shading to electric blue in upper half and at tip; bracts much reduced, ovate throughout inflorescence, 1–2 × 1–4 mm. *Flowers* sessile, suberect in bud stage, spreading at flowering stage, oblong-urceolate, pale greenish yellow, with conspicuous, pale to bright magenta lower, inner tepal; perianth tube cup-shaped, cream-coloured, with or without a very pale blue tinge, 2–3 mm long; outer tepals ovate, 7–8 × 4–5 mm, cream-coloured at base, shading to yellowish green above, with bright green keels and gibbosities; inner tepals obovate, tips slightly recurved, protruding well past outer tepals, upper inner tepals translucent dull white, overlapping, 9–10 × 5 mm, with bright green keels; lower inner tepal deeply canaliculate, 10–11 × 3–4 mm, lower half translucent dull white, upper half pale to bright magenta with pale greenish yellow keel. *Stamens* included within perianth, declinate; filaments white, 7 mm long; anthers dull maroon prior to anthesis, yellow at anthesis. *Ovary* ellipsoid, 3–4 × 2 mm, pale green; style 6–7 mm long, white. *Capsule* ellipsoid, 8 × 5 mm, bright green. *Seed* ovoid, 1.7 × 1.0 mm, shiny black with short, ridged strophule, up to 0.4 mm long. *Flowering time*: late July to mid-August. Figure 4.



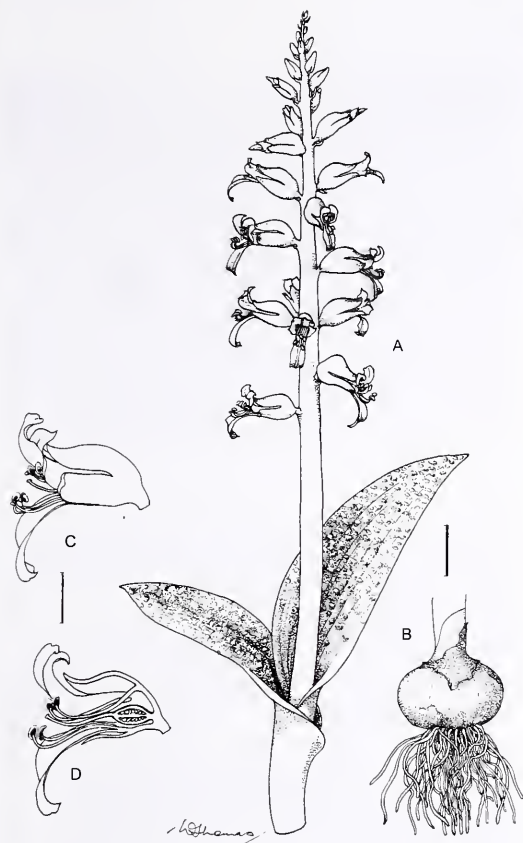


FIGURE 4.—*Lachenalia valeriae*. A, foliage and inflorescence; B, bulb; C, single flower; D, l/s flower. Scale bars: A, B, 10 mm; C, D, 5 mm. Artist: Vicki Thomas, drawn from type, Duncan 444 (NBG).

**Etymology:** *Lachenalia valeriae* is named for Valerie Fay Anderson (Mrs R. Geary-Cooke), in recognition of the wonderful contribution she has made to the knowledge of the flora of southern Africa, through the medium of watercolour paintings.

**Diagnostic features and affinities:** *L. valeriae* falls into the small group of species with sessile, urceolate or oblong-urceolate flowers with included, declinate stamens, its closest relatives being *L. framesii* W.F.Barker and *L. carnosa* Baker. *L. valeriae* is recognized by its moderately dense inflorescence of patent, oblong-urceolate, pale greenish yellow flowers with the deeply canaliculate lower inner tepal distinctly longer than the two upper lateral tepals, and conspicuously marked with pale to bright magenta in the upper half (Figure 4). The inner tepals are all slightly recurved at their tips, and the outer tepals have bright green gibbosities and keels. Mature bulbs always produce two opposite, spreading or suberect, slightly canaliculate, broadly lanceolate or narrowly ovate leaves with depressed longitudinal veins on the upper surface, which is densely covered with minute, rounded green pustules. The clasping leaf base is usually plain yellowish green but may also be heavily flushed with dark maroonish magenta. The white, subglobose bulb is surrounded by pale to dark brown, membranous

outer tunics and its relatively large, ovoid seeds have a shiny black testa and a short, ridged strophule.

*Lachenalia framesii* resembles *L. valeriae* in the shape of its yellow or greenish yellow, oblong-urceolate flowers with the upper part of the inner tepals recurved, and in the similar pale to bright blue upper portion of the rachis, but its flowers are much smaller and the upper part of its inner tepals are all pale to bright magenta, whereas in *L. valeriae* only the lower inner tepal has this colouring. *L. framesii* also differs in being a dwarf species with much shorter, suberect flowers, and it has much shorter, suberect, canaliculate, narrow-lanceolate leaves with strongly undulate margins, and the upper leaf surface is always smooth. Its bulb is globose and much smaller than that of *L. valeriae*, and its globose seeds are minute in comparison, and have a reticulate, matt black testa. *L. framesii* is a common species throughout central Namaqualand and the Knersvlakte, and its distribution extends close to that of *L. valeriae* in the Komaggas Flower Reserve, but does not overlap that of *L. valeriae*, which occurs west of this area. It usually occurs on flats in large colonies in quartzitic sand.

The similar urceolate flowers of *L. carnosa* are shorter and wider than those of *L. valeriae* and have dull white perianth segments, with all the inner tepals having broad, pale to dark mauve tips, and the gibbosities dark purplish brown. Its two spreading or suberect leaves differ in being broadly ovate and flat, with a distinct purplish maroon, cartilaginous margin, whereas those of *L. valeriae* are broadly lanceolate to narrowly ovate, and slightly concave. The upper surface of *L. carnosa* is almost always smooth but may occasionally have irregularly scattered, large flattened brown pustules, whereas those of *L. valeriae* are always covered with numerous small green, rounded pustules. The bulb tissue of *L. carnosa* is usually pale to dark yellow, surrounded by strong, dark brown tunics, whereas that of *L. valeriae* is always white. The similarly shaped, ovoid seeds of *L. carnosa* are less than half the size of those of *L. valeriae*, and like this species, also have a short, ridged strophule. *L. carnosa* is a very common species in central and western Namaqualand, and the Kamiesberg, where it usually grows in cracks and depressions of granite outcrops in sandy soil, or less frequently in sandy gravel on open flats. Its distribution does not overlap that of *L. valeriae*, but comes close to it in the Komaggas area.

**Distribution and habitat:** *L. valeriae* is currently known from five populations in the sandy coastal plain of northwestern Namaqualand in the Succulent Karoo Biome, where it occurs in shallow or deep brownish red sand on east- and west-facing slopes of granite outcrops (Figure 5). At its type locality near the mouth of the Buffels River in the Kleinsee Nature Reserve, it occurs only on west-facing slopes, near to or amongst low succulent vegetation including *Aloe framesii*, *Pelargonium fulgidum* and several *Crassula* and *Euphorbia* species, but at a locality just north of Kleinsee it is found on both east- and west-facing slopes. Individuals grow singly or in colonies on rock depressions and in between rock cracks (Figure 6), either in full sun or in partial shade of the surrounding vegetation. The distribution of *L. valeriae* needs to be further investigated north of Kleinsee, as



FIGURE 5.—Distribution of *Lachenalia valeriae*.

it is likely that it extends all the way up the coast to the mouth of the Holgat River, which is currently its northernmost limit.

#### Material examined

NORTHERN CAPE.—2816 (Oranjemund): Holgat River mouth, 1.6 km east of road, in sand dunes, (–DC), *Wisura* 1610 (NBG); 2917 (Springbok): Kleinsee Nature Reserve, (–CA), *Duncan* 444 (NBG); 2 km N of Kleinsee, (–CA), *Duncan* 448 (NBG); 8 km W of Komaggas, (–CD), *Lavranos* 28585 (NBG).

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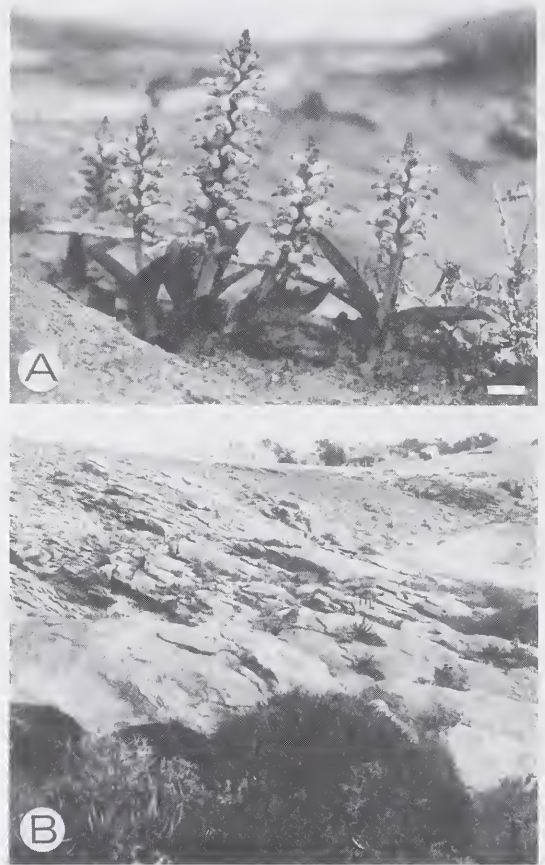


FIGURE 6.—*Lachenalia valeriae*, Kleinsee Nature Reserve. A, group of flowering plants; B, natural habitat on west-facing granite slopes. Scale bar: 10 mm.

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## ASTERACEAE

A DISTINCTIVE NEW SPECIES OF *FELICIA* (ASTEREAE) FROM WESTERN CAPE, SOUTH AFRICA

## INTRODUCTION

*Felicia* Cass. is a genus of 83 species of annuals, perennials and shrubs of tribe Astereae of the Asteraceae (Grau 1973). The genus is centred in southern Africa but a few species extend into tropical Africa as far north as Nigeria, Ethiopia and the Arabian Peninsula (Bremer 1994; Herman *et al.* 2000). *Felicia* is distinguished from related genera of the Astereae by an epaleate receptacle, uniseriate pappus of numerous barbellate bristles, ecaudate anthers and strongly compressed cypselas with swollen margins. Most species have blue or mauve to pink rays (rarely white or yellow) and yellow disc florets (Grau 1973). The species described here, *F. josephinae*, is remarkable in the genus for its broad white or cream-coloured ray florets and deep purple disc florets. Similarly coloured disc florets are otherwise known in the genus only in *F. heterophylla* (Cass.) Grau. *Felicia* is well represented by 54 species in the Cape Floral Region and *F. josephinae* was listed as *Felicia* sp. 1 in the account prepared for the recent conspectus of the Cape flora (Goldblatt & Manning 2000). Additional collections made in the spring of 2001 have enabled us to describe it formally.

***Felicia josephinae* J.C.Manning & Goldblatt, sp. nov.**

Herba annua usque ad 200 mm alta hispida, foliis inferioribus oppositis oblanceolatis, capitulis heterogamis radiatis solitariis pedunculis usque ad 50 mm longis trichomatibus glanduliferis vestitis insidentibus, involucri anguste ovoideo  $\pm 5$  mm alto et 4 mm in diametro, bracteis involucrialibus biseriatis supra medium trichomatibus glanduliferis et setis sparsis ornatis marginibus membranaceis apicibus ciliatis, flosculis radii 8 vel 9 ligula elliptico-oblanceolata, alba ad cretina epapposa, flosculis disci 14 vel 15 atropurpureis cylindricis supra dilatatis setis pappi  $\pm 25$  barbellatis et prope medio subplumosis, cypselis obovatis compressis marginibus incrassatis trichomatibus adpressis vestitis palide brunneis.

TYPE.—Western Cape: 3218 (Clanwilliam), hills between Elands Bay and Leipoldtville, deep sands, (–BC), 15 Sept. 2001, Goldblatt & Porter 11887 (NBG, holo.; K, MO, PRE, S, iso.).

Annual herb 150–200 mm high, branching near base; stems sparsely leafy, hispid with short and long multicellular hairs and with numerous shortly stipitate glands in upper parts. Leaves decreasing in size up stem; lower leaves opposite, soon withering, oblanceolate, 30–70  $\times$  6–13 mm, narrowed to petiole-like base, thinly hispid with long multicellular hairs; upper leaves mostly alternate, becoming progressively lanceolate to linear, hispid with long and short multicellular hairs. Capitula heterogamous, radiate, solitary on terminal and axillary peduncles up to 50 mm long, with few, scattered, subulate bracts. Involucre narrowly ovoid,  $\pm 5$  mm high and 4 mm diam.;

involucral bracts biseriate, 11–13, glandular-hairy and thinly setose in upper half, 4–5 mm long, with scarious margins and ciliate tips, outer bracts linear with narrow margins,  $\pm 1$  mm wide, inner bracts oblanceolate with broad margins,  $\pm 1.5$  mm wide. Receptacle flat, epaleate, alveolate. Ray florets female, 8 or 9; tube cylindrical, glandular-hairy, 2.5–3.0 mm long; lamina spreading, elliptic-oblanceolate, 10–12  $\times$  4–6 mm, 4-veined, white to cream-coloured. Ovary narrowly elliptic, adpressed-hairy; style terete with linear branches, not or shortly exerted, branches  $\pm 1$  mm long, acute, margins stigmatic. Pappus absent. Cypselas obovate, 2.5–3.0  $\times$   $\pm 1.5$  mm, flattened with thickened margins, faces and margins covered with adpressed hairs, pale brown. Disc florets bisexual, 14 or 15, deep purple, inner florets functionally male; tube cylindrical but widening slightly in upper part, glandular-hairy, 2.5–3.0 mm long, limb obliquely obconical, 5-lobed; lobes triangular, recurved,  $\pm 1 \times 0.8$  mm, with thickened margins. Anthers  $\pm 2$  mm long including ovate, somewhat keeled apical appendage, deep blue with white pollen; anther base obtuse, ecaudate. Ovary narrowly elliptic, adpressed-hairy; style terete, branches  $\pm 1$  mm long, purple, incurved, linear, flattened with stigmatic margins and sterile, triangular, papillate apical appendages. Pappus bristles uniseriate,  $\pm 25$ , spreading in fruit, caducous, 3–4 mm long, barbellate but subplumose near middle, connate at base into short collar, white. Cypselas as in ray florets. Flowering time: September and October. Figure 7.

**Distribution and biology:** *Felicia josephinae* has only been collected from a small area along the Western Cape coast between Elands Bay and Lambert's Bay, extending inland to Sandberg, east of Leipoldtville (Figure 8). It occurs on hills and dunes, where it is restricted to Strandveld Succulent Karoo (Low & Rebelo 1996). This strand vegetation occurs on deep, calcareous sands in a belt along the coastal plain and is dominated by scattered shrubs, especially *Salvia lanceolata* (Lamiaceae), *Nylandtia spinosa* (Polygalaceae) and succulent species of *Euphorbia* (Euphorbiaceae). Numerous annual species flourish seasonally in the open spaces between the shrubs, including *Alonsoa unilabiata*, *Hemineris racemosa*, *Lyperia tristis*, *Nemesia affinis* and *N. bicornis* (Scrophulariaceae), and *Arctotis hirsuta*, *Dimorphotheca pluvialis* and *Trichogyne verticillata* (Asteraceae). Although Strandveld Succulent Karoo extends along the coast for some 500 km, *F. josephinae* appears to be restricted to the extreme southern part where the sands are relatively shallower and overlie more solid sandstone-derived substrates.

**History:** *F. josephinae* appears to have been first collected in September 1933 by C. Louis Leipoldt, poet, author, medical practitioner and plant collector, from between Elands Bay (incorrectly transcribed on the herbarium labels as Elandskloof) and Clanwilliam, on the Western Cape coast. During the ensuing two decades a handful of further collections were made by various Cape botanists, all from the same small stretch of coun-

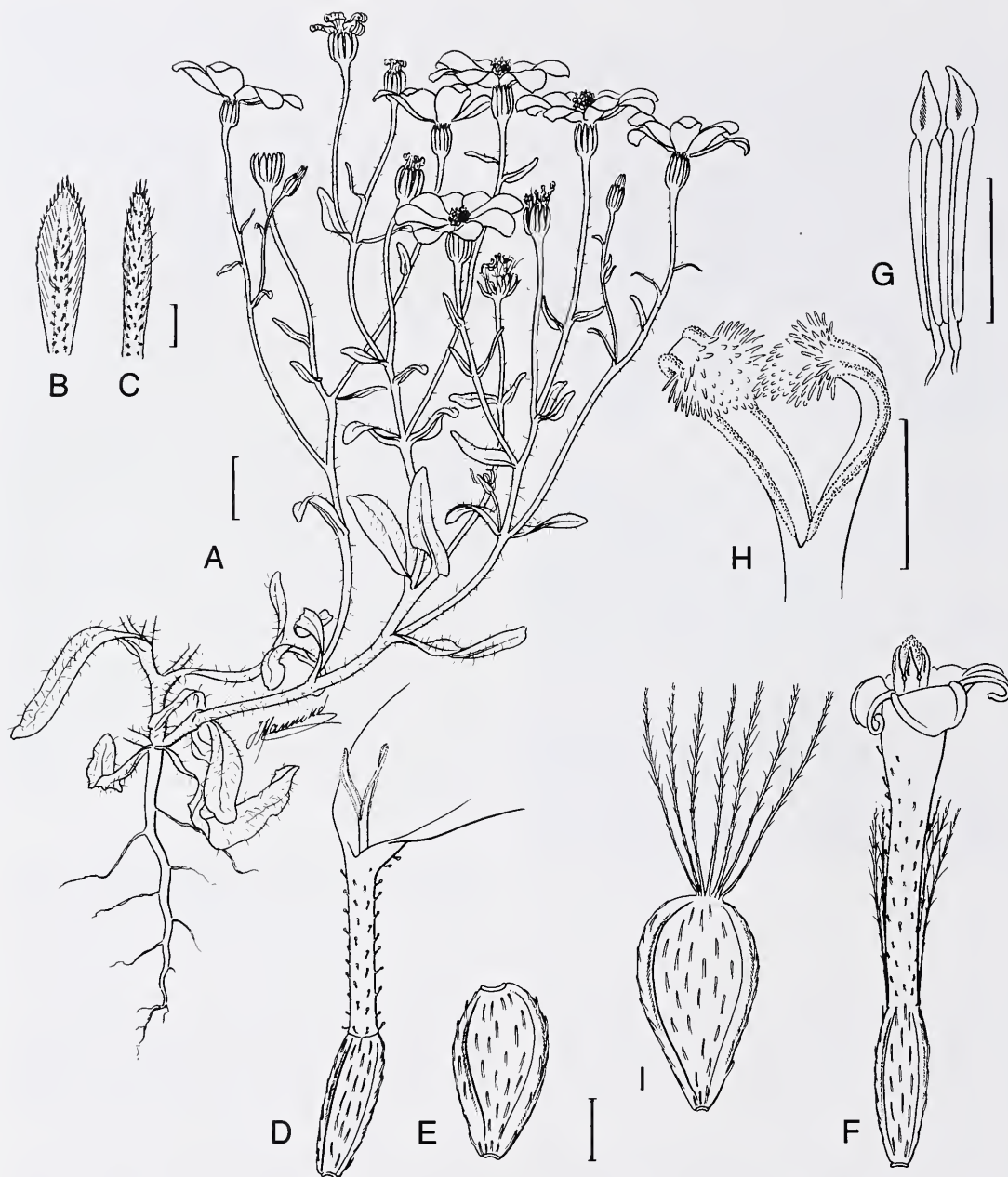


FIGURE 7.—*Felicia josephinae*. A, whole plant. B, C, involucre bracts: B, inner; C, outer. D, E, ray floret: D, floret; E, cypsel. F–I, disc floret: F, floret with pappus bristles removed from front; G, two stamens; H, stigmatic branches; I, cypsel (rear pappus bristles not shown). Scale bars: A–C, 10 mm; D–I, 1 mm. Artist: John Manning.

try between Elands Bay and Lambert's Bay. These early collections were all identified either as a new species or, rather tentatively, as a variant of *Chareis heterophylla* Cass. [now *Felicia heterophylla* (Cass.) Grau]. None of these collections was apparently seen by Grau (1973) for his revision of the genus. *F. josephinae* first came to our attention in 1995 when we found it on the Farm Sandberg, east of Elands Bay, possibly at or very near the spot at which Leipoldt had originally located it. It was clear to us then that it was not a form of *F. heterophylla*.

We encountered it again in the spring of 2001, at which time we took the opportunity of collecting material for description and illustration. It gives us great pleasure to name it for our colleague, Josephine Beyers, in recognition of her long interest in the Asteraceae.

**Diagnosis and relationships:** this distinctive, highly floriferous species is readily distinguished from all other species of *Felicia* by its broad, white or cream-coloured rays and deep purple disc. The rounded plants become



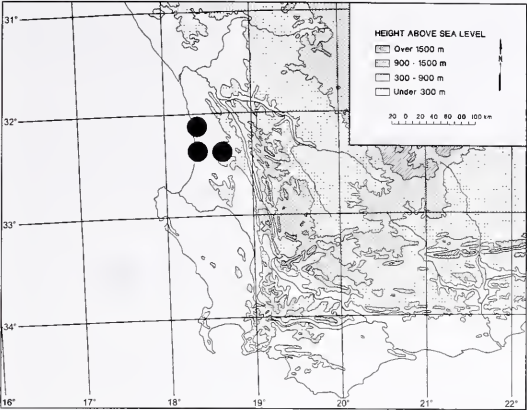


FIGURE 8.—Distribution of *Felicia josephinae* in Western Cape.

covered with dainty white flower heads that in their broad rays and small, convex, purple discs are quite unlike any other species of *Felicia*. The central disc florets, which are functionally male, have somewhat longer ovaries than the surrounding florets, with the result that the disc is conspicuously convex and projects prominently above the rays. *F. josephinae* is one of a handful of annual species in section *Neodetris* Grau that have a strictly biseriate involucre and that lack pappus bristles on the ray florets. Among these species it appears to be most closely allied to *F. heterophylla*, the only other species in the genus known to have blue or purple disc florets. The two species also resemble one another in their involucre bracts, which bear both glandular and setose hairs, in their cypselas, which are rather scantily clad with long hairs, and in their subplumose pappus bristles. *F. josephinae* is distinguished from *F. heterophylla* by its relatively broader (10–12 × 4–6 mm vs 15 × 4 mm) rays that are white to cream-coloured rather than deep blue, by the shorter peduncles (30–50 mm long vs 50–150 mm long), resulting in a more compact appearance to the plants, and by the narrower involucre (4 mm vs 6–8 mm diam.) that contain relatively few disc florets in which the petal lobes are conspicuously recurved rather than suberect or slightly recurving. Herbarium material of the two species in which the

colour of the rays has faded or is not noted, can always be separated by the characteristically short peduncles and compact habit of *F. josephinae*. The species appears to have significant horticultural potential.

Additional material examined

WESTERN CAPE.—3218 (Clanwilliam): Lambert’s Bay, Otterdam, 6-09-1953, (–AB), *Compton* 24170 (NBG); Elands Bay, base of Rooikransberg, 18-10-1935, (–AD), *Pillans* 8035 (BOL); between Elands Kloof [sic] and Clanwilliam, (–BC), 09-1933, *Leipoldt* 21268 (BOL); between Elands Bay and Leipoldtville, (–BC), 09-1947, *Zinn s.n.* (SAM); Farm Sandberg, east of Leipoldtville, sandy slopes of Sandberg, (–BC), 27-09-1995, *Goldblatt & Manning* 10325 (MO, NBG).

ACKNOWLEDGEMENTS

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PTERIDOPHYTA

A NEW FERN RECORD FOR THE FLORA OF SOUTHERN AFRICA REGION

*Asplenium unilaterale* (Figure 9) is a widespread fern of the Old World tropics; on continental Africa it is fairly common in West Africa, becoming less frequent south of the equator. In the *Flora zambesiaca* region it is confined to three known localities: in Malawi from the Misuku Hills and Thyolo Mtn, and in Zimbabwe from a single locality in Chirinda Forest. Its recently discovered occurrence in the northern mountains of Swaziland therefore represents an intriguing southward extension of its distribution. It is also interesting to note that the valley in which this fern occurs is also occupied by an isolated population of the tree *Trilepisium madagascariensis* DC. (Moraceae) (Burrows & Burrows in press), a

species with which it is always associated where it is found in Zimbabwe and Malawi, suggesting that these two taxa are possibly the last surviving remnants of a relict vegetation type which persists in this hidden valley.

The plants were found growing on the wet margins of a rivulet flowing over rocks, in deep shade of evergreen forest. Although only one small population was seen, it is probable that other groups occur on the several other suitable sites in this valley. Since the locality is only ± 1 km from the South African border, it is also possible that *A. unilaterale* occurs on the South African side. This ribbon of forest is severely threatened by several species of invading

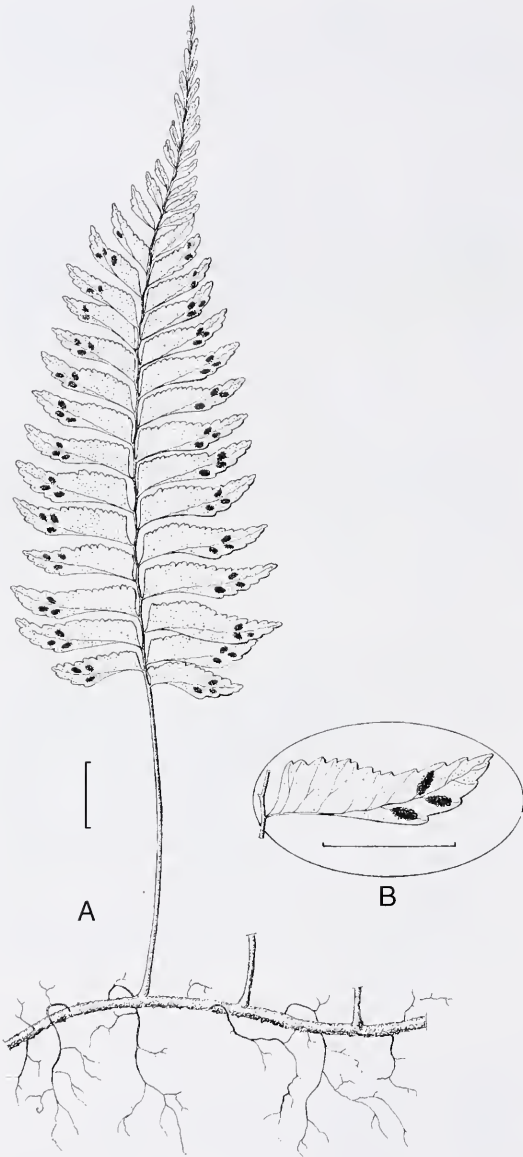


FIGURE 9.—*Asplenium unilaterale*, J.E. & S.M. Burrows 7693, A, frond and rhizome; B, median pinnae. Scale bars: 15 mm. Artist: S.M. Burrows.

alien plants, particularly *Chromolaena odorata* (Asteraceae) and *Solanum mauritianum* (Solanaceae). Somewhat

lesser threats at present include the uncontrolled harvesting of medicinal plants, and the clearing of the forest for the cultivation of *Cannabis sativa* (Cannabaceae).

***Asplenium unilaterale* Lam.**, Encyclopédie méthodique. Botanique 2,1: 305 (1786); Sim: 152 (1915); Tardieu-Blot: 182, t. 37 (1953); Tardieu-Blot: 189 (1958); Alston: 56 (1959); Tardieu-Blot: 195, t. 29 (1964); Schelpe: 174 (1970); W.B.G.Jacobsen: 340, t. 250 (1983); J.E.Burrows: 222, t. 50 (1990); J.E.Burrows & S.M.Burrows: 92 (1993). Type: Mauritius, *Commerson s.n.* (P-LA).

*Asplenium resectum* Sm.: t. 72 (1791). Type: Réunion, *Commerson (Thouin) s.n.* (P).

SWAZILAND.—2531 (Komatipoort): Ntfontjeni Dist., Wyldsdaal Farm, Ugutugulu River, 25° 48.36'S, 31° 17.01'E, 600 m, (–CD), 11 May 2002, J.E. & S.M. Burrows 7693 (K, LYD, NBG, NU, PRE, SDNH, Buffelskloof Herb.).

ACKNOWLEDGEMENTS

Bob Johns of the Royal Botanic Gardens, Kew, is thanked for tracing types.

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PORTULACACEAE

THE SYNONYMY OF *CERARIA NAMAQUENSIS* (SOND.) H.PEARSON & E.L.STEPHENS

In his description of *Ceraria namaquensis* (Sond.) H.Pearson & E.L.Stephens, Dyer (1984) suggests that *C. gariepina* H.Pearson & E.L.Stephens should probably be regarded as a synonym of the former name. Pearson & Stephens (1912) had separated the two taxa as follows:

- 'Living stems not readily inflammable. Surface of stem dull grey. Leaves 3–4.5 mm long . . . . . *C. namaquensis*
- 'Living stems readily inflammable. Surface of stem pale yellow. Leaves less than 2 mm long . . . . . *C. gariepina*'

However, Dyer (1984) reports that cultivated material at the Pretoria National Botanical Garden that was other-



wise identified as *C. gariepina*, only burned when dry. Leaves of specimens in PRE show a continuous range from 2.0 to 4.5 mm long, often on the same specimen. Many plants, indeed nearly all the specimens in PRE, have both grey and yellowish branches. In fact, the PRE duplicate of Pearson *s.n.* in *Percy Sladen Memorial Expedition 3789* (an isosyntype of *C. gariepina*) has dark coppery brown stems, a colour matched by the long-leaved specimens *Pole Evans 2250* (PRE) and *Tölken 5308* (PRE).

It may be concluded that the distinguishing characters given by Pearson & Stephens (1912) are not constant in practice. Examination of the specimens in PRE has failed to yield any other characters which can be used to distinguish between these two taxa, and they have been regarded informally as one for many years.

With the production of a major new work on the southern African flora at PRE, it has become necessary to regularise the position of informal decisions such as this, and the purpose of this note is to place on record the reasons for the following synonymy.

***C. namaquensis* (Sond.) H.Pearson & E.L.Stephens** in *Annals of the South African Museum* 9: 33 (1912); Podlech: 8 (1967); Dyer (1984).

*Portulacaria namaquensis* Sond. 2: 386 (1862).

*C. gariepina* H.Pearson & E.L.Stephens 9: 33 (1912), *synon. nov.*

The names are typified by two syntypes each. As it has not yet been possible to examine all four gatherings with type status, no lectotypes are chosen at this stage.

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## AMARYLLIDACEAE

### THE TYPIFICATION OF *CYRTANTHUS SMITHIAE* WATT EX HARV.

#### INTRODUCTION

While researching a collection of original water colour paintings of South African flora by John and Margaret Herschel, executed at the Cape between 1834 and 1838, a painting was found in the collection which appears to have an important bearing on the typification of the name *Cyrtanthus smithiae* Watt ex Harv. The original plate is in the Brenchurst Library, Johannesburg—no. 53 in the Herschel collection (Warner & Rourke 1998).

*Cyrtanthus smithiae* is similar to *C. helictus* Lehm. and, as there has been some confusion between the two (Dyer 1939), it is important to typify these names as accurately as possible.

#### TYPE OF *CYRTANTHUS SMITHIAE*

Harvey's name *Cyrtanthus smithiae* is based on the following brief description which appeared under the generic account of *Cyrtanthus* in his *Genera of South African plants* (1838): 'There are several species, one of the most elegant of which, *C. Smithiae*, Watt MSS. was brought from Cafferland by Mrs Col. Smith, in 1836, and blossomed in Mr Watt's garden at Rondebosch last year. It has large white flowers, each segment marked with a rose coloured band, and spiral strap-shaped leaves'.

The Mr Watt, to whom Harvey attributes the name, is James Duff Watt, Deputy Assistant Commissary General, who lived at Mowbray Place, Rondebosch. No mate-

rial seems to have been preserved or, if it was, it appears to have been lost, as Dyer (1939), who was the first to recognize this name, did not cite a type specimen in his account of this species. The curator of the herbarium at Trinity College Dublin (TCD) confirms that there is no material of *Cyrtanthus smithiae* in Harvey's herbarium (M. Foody pers. comm.). Dyer's interpretation of the name *C. smithiae* was evidently based on the above brief but sufficient description.

Two years after Harvey's description appeared, Herbert (1840) published *Cyrtanthus smithianus* Herbert, based on the same collection—a bulb from Caffraria collected by Mrs Smith and sent to him by Watt & Harvey. Apparently he was unaware of Harvey's earlier name. It subsequently flowered in Herbert's garden in England from which Herbert's description was prepared. Again, no type material seems to have been preserved and no illustration was published. Some of Herbert's types are at Kew but both Baker (1896) and Dyer (1939) failed to trace any material used by Herbert in his description of *Cyrtanthus smithianus*. As the Herschels' watercolour was also based on the same collection—collected by Mrs Juana Smith (wife of the then Col. Harry Smith)—it has particular relevance to the typification of the name *Cyrtanthus smithiae* as well as the later name, *C. smithianus*.

The Herschels' painting is annotated '*Cyrtanthus smithiae*' in Sir John Herschel's hand and is dated 'Dec. 27 1837', the same year in which Harvey had described a flowering specimen from Mr Watt's garden. However, a day before the painting was made, Col. and Mrs Smith



FIGURE 10.—Lectotype of *Cyrtanthus smithiae* Watt ex Harv., outlined in pencil using a *camera lucida* by Sir John Herschel and painted in water colour by Margaret Herschel on 27th December 1837. Mrs Juana Smith brought the bulbs from 'Cafferland' in 1836. Plate 53, Herschel collection, Brenthurst Library, Johannesburg. Photo: Clive Hassall.

dined with the Herschels at Feldhausen, on Dec. 26th 1837, according to Sir John Herschel's diary [Evans *et al.*: 333 (1969)]. Knowing the Herschels' interest in botanical matters, it was clearly the Smiths themselves who brought John and Margaret Herschel the flowering specimen of the *Cyrtanthus* which Mrs Smith had also given to Mr J.D. Watt where Harvey had originally examined it. It is therefore reasonable to assume that the Herschels fine colour plate is the only visual image we have of part of the type collection of *Cyrtanthus smithiae* (Figure 10). This plate can therefore be regarded as having the status of a lectotype and is here designated as such. (See Warner & Rourke 1998, plate 110 for a colour reproduction of this illustration.) In following this line of argument one must assume that Mrs Juana Smith made a single collection of this particular *Cyrtanthus*, that all the material was of the same species, and that there were sufficient bulbs to distribute to Mr J.D. Watt, in Rondebosch, Cape Town, William Herbert in England and also the Herschels in Cape Town.

#### SYNONYMY

***Cyrtanthus smithiae* Watt ex Harv.**, Genera of South African plants: 338 (1838); Dyer: 100 (1939); Reid & Dyer: 38 (1984). Type: Cafferland, Mrs Smith, watercolour painting by J.F.W. Herschel and M.B. Herschel, plate 53 labelled *Cyrtanthus Smithiae* in J.F.W. Herschel's hand, in Brenthurst Library (lecto.!, here designated).

*Cyrtanthus smithianus* Herbert in Curtis's Botanical Magazine 66 sub. tab. 3779 (1840); Baker: 227 (1896). Type: Caffraria, Mrs Smith, plate 53 labelled *Cyrtanthus Smithiae* by J.F.W. Herschel and M.B. Herschel in Brenthurst Library (lecto.!, here designated).

#### ACKNOWLEDGEMENTS

I am grateful to the Brenthurst Library, Johannesburg, for having the original Herschel painting of *Cyrtanthus smithiae* photographed for this article and for permission



to reproduce it here. Miss Mary Foody, Dept. of Botany, Trinity College, Dublin, kindly searched the Harvey herbarium at Trinity College, for material of *Cyrtanthus smithiae*.

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# A study of ovule-to-seed development in *Ceratosicyos* (Achariaceae) and the systematic position of the genus

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**Keywords:** Achariaceae, *Ceratosicyos* Nees, embryology, fringe layer, sarcotesta, seed coat, transfer cells

## ABSTRACT

A light microscope study of developing ovules and seeds of *Ceratosicyos laevis* (Thunb.) A.Meeuse was undertaken to augment an investigation of ovule and seed structure in Achariaceae, a tri-generic family comprising three species of herbaceous perennials endemic to southern Africa. Tests for myrmecochory suggest that seed of *Ceratosicyos* Nees is not dispersed by ants like those of *Acharia* Thunb. and *Guthriea* Bolus. Structural differences include the absence of a raphe ridge and imbibition lid and the presence of long funicles and medium-sized embryos in *Ceratosicyos*.

## INTRODUCTION

*Ceratosicyos laevis* (Thunb.) A.Meeuse is one of three species of herbaceous, dicotyledonous perennials that make up an entire family of southern African endemics, the Achariaceae. The family is regarded as highly modified and its relationships have been much debated (see e.g. Bernhard 1999; Steyn *et al.* 2001 and references therein). Traditionally, Achariaceae were placed among families belonging to Violales (Dahlgren 1980). Based on evidence from phylogenetic analyses of molecular data (Savolainen *et al.* 2000) the family is placed in Malpighiales, where it has been linked with Kiggeliaceae which consists of woody perennials from southern and East tropical Africa (*Kiggelia* L.), Assam and Burma (*Gynocardia* R.Br.) and Sri Lanka and Malaysia (*Trichadenia* Thwaites).

In niche preferences and vegetative morphology, the three herbaceous species of Achariaceae are so diverse (Dahlgren & Van Wyk 1988) that they were placed in separate genera. Yet, in breeding habit and floral structure *Ceratosicyos laevis* shares many characters with *Acharia tragodes* Thunb. and *Guthriea capensis* Bolus. Notable similarities include the presence of few-flowered inflorescences containing both male and female flowers, absence of rudimentary organs of the opposite sex in the unisexual flowers, sympetaly (petals loosely coherent in *Ceratosicyos* Nees), conspicuous (yellowish), antipetalous floral glands, and anthers with broad connectives and unusual, swollen trichomes (Dahlgren & Van Wyk 1988; Bernhard 1999). In addition, recent reproductive biological studies in Achariaceae have shown that ovules and seed characters in *Acharia* Thunb. and *Guthriea* Bolus are remarkably similar (Steyn *et al.* in press). Furthermore, both genera are myrmecochorous and their seeds have the same unusual adaptations for seed germination and dispersal, namely an imbibition lid and a pronounced raphe ridge to serve as a handle for

carrying the smooth seed.

For *Ceratosicyos*, very little information is available on ovule and seed structure or seed dispersal. A brief report on ovule structure by Bernhard (1999) and a reference to seed coat structure (exotegmy, according to Dahlgren & Van Wyk 1988) suggest important embryological differences between *Ceratosicyos* and *Acharia* or *Guthriea*. It is not known whether *Ceratosicyos* also forms part of the herbaceous myrmecochorous flora of southern Africa—it does not bear its fruit near the ground like *Acharia* and *Guthriea* for easy collection by ants, but is a vigorously growing, nontendrilliferous twiner that reaches considerable heights along streams at the edge of Afromontane forest, particularly along the eastern escarpment of southern Africa.

For the present study we investigated embryo sac formation, mature ovule characters, ovule-to-seed development and mature seed and seed coat structure in *Ceratosicyos*. We also tested the seed for possible dispersal by ants. Results are compared with those recently obtained on *Acharia* and *Guthriea* (Steyn *et al.* 2001; Steyn *et al.* in press) to determine the embryological characters of the family and to evaluate our findings in the light of available embryological data on *Kiggelia* L.

## MATERIAL AND METHODS

Floral buds, mature female flowers and developing fruit of *Ceratosicyos* were collected in Eastern Cape from a population growing on the banks of the Maitland River, in the Maitland River Forest Reserve (voucher specimen: Van Wyk 13555 PRU). Additional material that included seeds at dispersal stage was gathered at Kowyns Pass near Graskop in Mpumalanga (voucher specimen: Steyn 24 PRE). All flowering and fruiting stages were immediately immersed and stored in a 0.1 M cacodylate-buffered solution (pH 7.4) containing 4% formaldehyde and 2.5% glutaraldehyde. Flowers and fruits were later dissected, ovules and developing seeds removed, sorted according to size and rinsed in the buffer. Dehydration and impregnation with glycol methacrylate (GMA) followed the methods of Feder &

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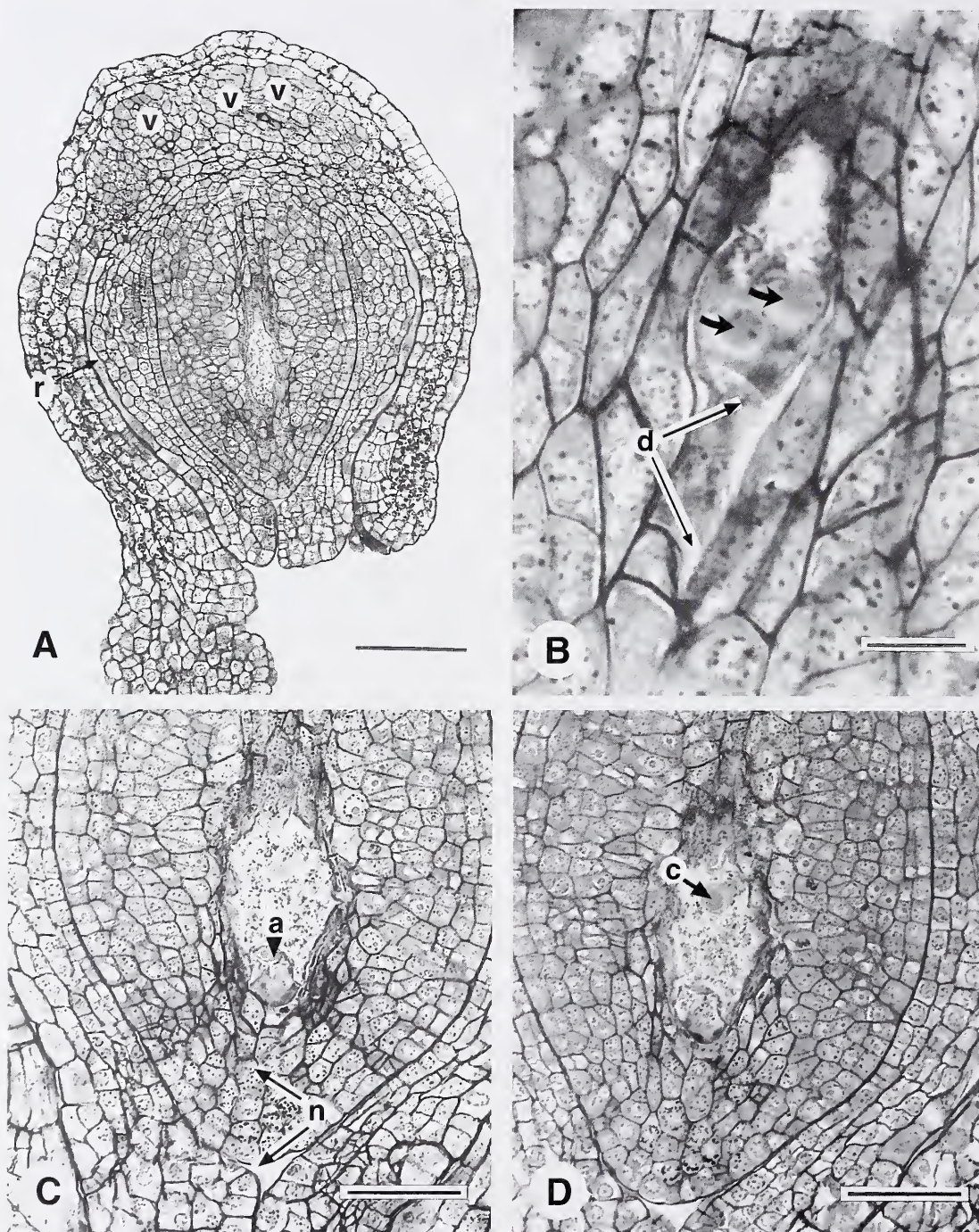


FIGURE 1.—Ovule and embryo sac of *Ceratostycos* as seen in sagittal section. A, mature ovule, B, early stage in development of bisporic embryo sac; C, D, consecutive sections of same ovule as in A to show details of mature embryo sac. a, egg cell; c, central cell nucleus; curved arrows indicate megaspore nuclei in chalazal dyad cell; d, disintegrating micropylar dyad cell; n, derivatives of nucellus epidermis; r, outer epidermis of inner integument; v, vascular bundles in chalaza. Scale bars: A, 100  $\mu$ m; B, 10  $\mu$ m; C, D, 50  $\mu$ m.

O'Brien (1968). A selection of impregnated structures was individually imbedded in GMA, hardened in the oven at about 58°C and sectioned transversely and sagittally. Selected sections were stained with the periodic acid/Schiff reaction and counterstained with toluidine

blue O by using the protocols of O'Brien & McCully (1981).

Tests for myrmecochory: at the collection site on the Kowyns Pass, dehiscing capsules were carefully removed



from the plants, the seeds collected and immediately strewn onto the trails or near the nests of ants of varying sizes found at the collection site. Mature capsules were stored in air-tight bags overnight and taken to Pretoria where seeds, removed from capsules that had in the meantime split open, were again offered to ants. Dried-out seeds with tuberculate surfaces were also offered to ants.

## RESULTS

### *Placentation and orientation of ovules*

The hypogynous female flowers of *Ceratosicyos* contain elongated, pentagonal ovaries borne on gynophores. The ovaries are unilocular and usually contain 7–15 anatropous ovules that are borne singly on five parietal placentae. The latter regions are not ridged and run longitudinally along the inner surface of the ovary wall, opposite the five median carpel traces. Ovules from five placentae are so arranged that they form a single row in the narrow locule and this alignment is maintained throughout ovule-to-seed development. The alignment is achieved by the ability to vary the orientation of the ovules and the lengths of the funicles—some ovules point upwards, others downwards and the funicles may be short or more than twice the length of the ovular body to place the ovules neatly in a single row.

### *Structure of mature ovule*

Mature ovules are anatropous, bitegmic, crassinucellate structures (Figure 1A) with an ovoid shape and  $\pm 520 \mu\text{m}$  long (funicle excluded). The integuments are multilayered, the outer consists of four to five layers in its central part, while the inner is up to seven layers thick in this region. The outer epidermis of the inner integument is very conspicuous—the cells are four to six times longer than any other cell in the ovule with the exception of the embryo sac. On the antiraphal side of the ovule, the tip of the outer integument increases in thickness by tangential divisions in its inner epidermal layer. In pre-fertilization stages of ovules, the outer integument is as long as the inner integument so that the micropyle canal is formed by the inner integument only. The raphe is not ridged. The vascular bundle of the raphe branches as soon as it enters the chalaza, but the integuments are not vascularized (Figure 1A).

The mature embryo sac is about one-third the length of the nucellar cylinder and lies in the centre of massive nucellar tissue. About six layers of nucellus cells cover the embryo sac on all sides. Below the micropyle, at least three of these layers result from periclinal divisions of the nucellus epidermis (Figure 1C, D). The nucellus apex is slightly attenuate, but does not protrude into the micropyle.

The embryo sac develops from the chalazal dyad cell while the micropylar dyad cell degenerates (Figure 1B). During the second meiotic division the chalazal dyad is not partitioned by a transverse cell wall so that both megaspore nuclei are included in the same cell (Figure 1B). After two mitotic divisions an eight-nucleate, bisporic embryo sac of the *Allium* Type is formed. The

mature embryo sac contains many starch grains. A small egg apparatus occurs below the parietal nucellar tissue (Figure 1C). The short neck regions of the synergids contain a filiform apparatus. A large central cell nucleus lies in about the central part of the embryo sac, while three ephemeral antipodal cells (not shown) develop in the elongated and narrow chalazal base (Figure 1A) of the embryo sac.

### *Early development of endosperm and embryo*

Fertilization is porogamous in *Ceratosicyos* and endosperm formation is nuclear. After entering the micropyle, the tip of the pollen tube swells and stains darkly with PAS and toluidine blue (Figure 2A). During the initial stages of embryo sac enlargement (Figure 2A), free endosperm nuclei become arranged in a single layer alongside the embryo sac wall. When the growing seed has reached a size of  $\pm 5 \times 2.5 \text{ mm}$ , the first cell walls are laid down between adjacent endosperm nuclei, and the embryo sac then gradually becomes filled, layer upon layer, with thin-walled endosperm cells.

The zygote remains inactive during the nuclear stage of endosperm formation. The first division of the zygote was not seen, but pro-embryos in the tetrad stage of development (Figure 2B) were found before the endosperm started to become cellular. These four-celled pro-embryos are T-shaped which shows that the apical cell (ca) has divided in a vertical plane and the basal cell (cb) transversely (Figure 2B). The two daughter cells of ca then both divide obliquely (Figure 2C) so that a bicellular, wedge-shaped epiphysis (e) is formed in the apical tier during the quadrant stage of the pro-embryo (i.e. when the derivatives of ca comprise four cells). The epiphysis later forms the shoot apex, whereas the remaining cells of the quadrant form the cotyledons (Natesh & Rau 1984: 390). The pro-embryo is globular in shape and has no suspensor. Below the cells of the quadrant, the uppermost derivative of cb is a discoidal cell (h), designated 'hypophysis' by Hanstein (1870). The hypophysis later forms the initials of the root cortex and the root cap (Cr  t   1963).

In Johansen's (1950) classification of embryogenic types, T-shaped pro-embryos are characteristic of both the Onagrad Type and Asterad Type, but it is only in the latter type that the basal cell (cb) contributes significantly to the formation of the embryo proper. *Ceratosicyos* embryos have no suspensors, all derivatives of the basal cell are incorporated into the embryo proper which indicates an Asterad Type embryo. The presence of the epiphysis also points towards the Asterad Type—it is in taxa conforming to this type that an epiphysis is formed during the quadrant stage (Natesh & Rau 1984: 386, fig. 8.6). The lack of a suspensor places the embryo of *Ceratosicyos* in the *Penaea* variation of the Asterad Type (Natesh & Rau 1984: 390, 414).

### *Development and structure of the seed coat*

The seed coat of *Ceratosicyos* is mainly derived from the outer integument. This integument forms the sarcotestal layers and the outer, wavy layer of sclereids that protrude peak-like into the sarcotesta (Figures 3D; 5D).



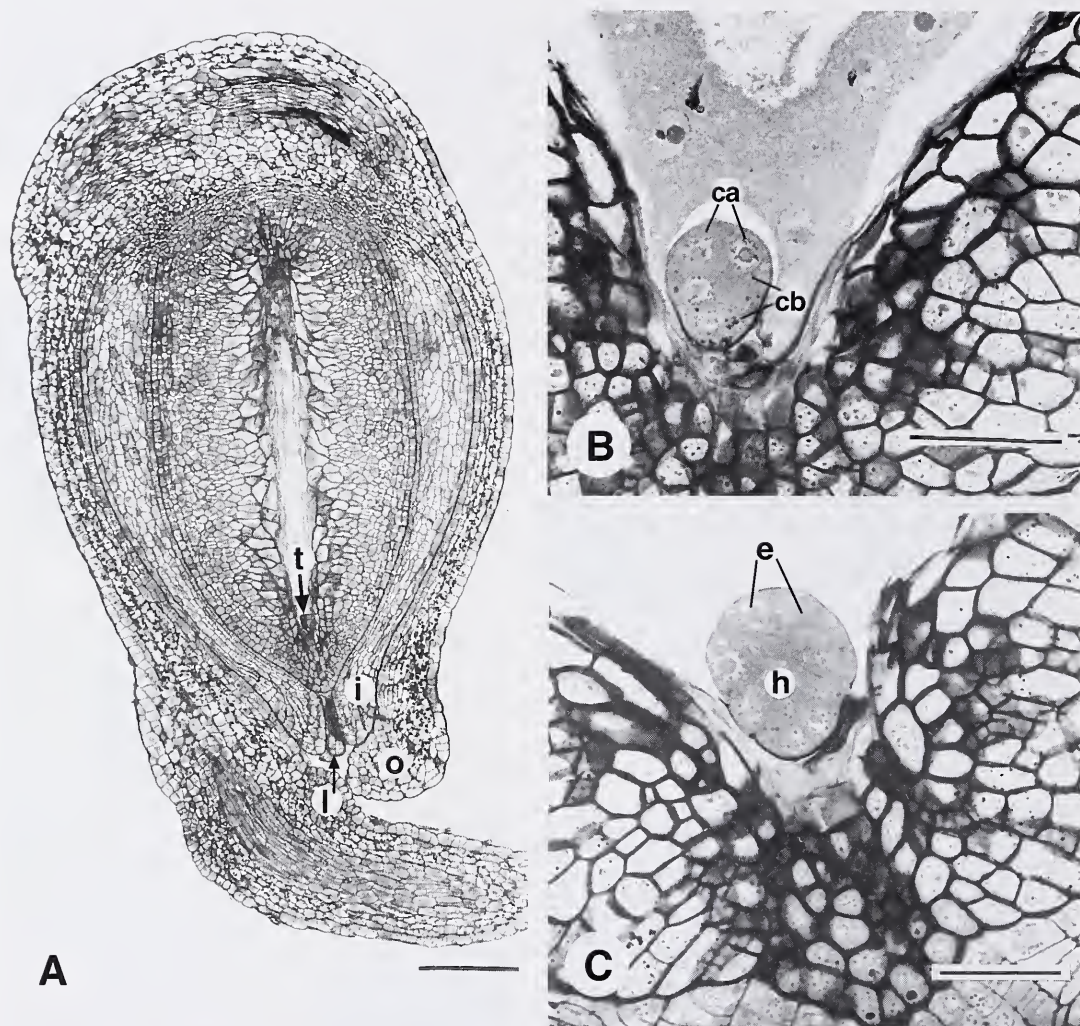


FIGURE 2.—Early development of endosperm and embryo in *Ceratiosicyos*. A, developing seed during resting stage of zygote; B, T-shaped pro-embryo; C, suspensorless pro-embryo during quadrant stage. ca, apical cell after vertical division; cb, basal cell after transverse division; e, epiphysis; h, hypophysis; i, inner integument, l, bulge of inner integument; o, outer integument participating in formation of micropyle canal; t, pollen tube in elongating embryo sac. Scale bars: A, 200  $\mu$ m; B–C, 50  $\mu$ m.

The inner integument contributes a few layers of periclinally elongated fibres to the seed coat. During seed coat development the cuticle between the outer and inner integument gradually disappears so that a study of the mature seed coat alone does not show which part each integument plays in the formation of the seed coat.

#### Contribution of the outer integument (testa) to the seed coat

In pre-fertilization stages, the outer integument consists of about five cell layers (Figure 1A), except at its rim where the number of layers increases through tangential divisions of the inner epidermis. The cells in the rim remain meristematic and in early post-fertilization stages the distal part of the outer integument grows beyond the inner integument to take part in the formation of the micropyle (Figure 2A). In developing seeds a layer of actively dividing endotestal cells (s) can be seen inside the developing sarcotesta (Figure 3A, B, D). These cells

are the derivatives of the inner epidermis of the outer integument. At first, the derivatives lie in radial rows and the layer is of even thickness (Figure 3A, B). When the seed has reached its final length of  $\pm 6$  mm, the endotestal layer becomes wavy and starts forming projections into the sarcotesta (Figure 3D). The endotestal cells later develop into closely packed, thick-walled sclereids with starch grains and single, large crystals of calcium oxalate in some of the cells, but the crystal-containing cells do not form a continuous layer. At seed dispersal stage, the contents of the endotestal sclereids stain intensely with toluidine blue, indicating the presence of phenolic substances (Figures 3C; 4A, B).

The epidermis and mesophyll of the outer integument form a sarcotesta that envelops the whole seed, including the chalaza and raphe. The raphal region is not pronounced, i.e. a raphal ridge is not formed (Figures 4A; 5D). The raphal bundle lies imbedded in thin-walled,



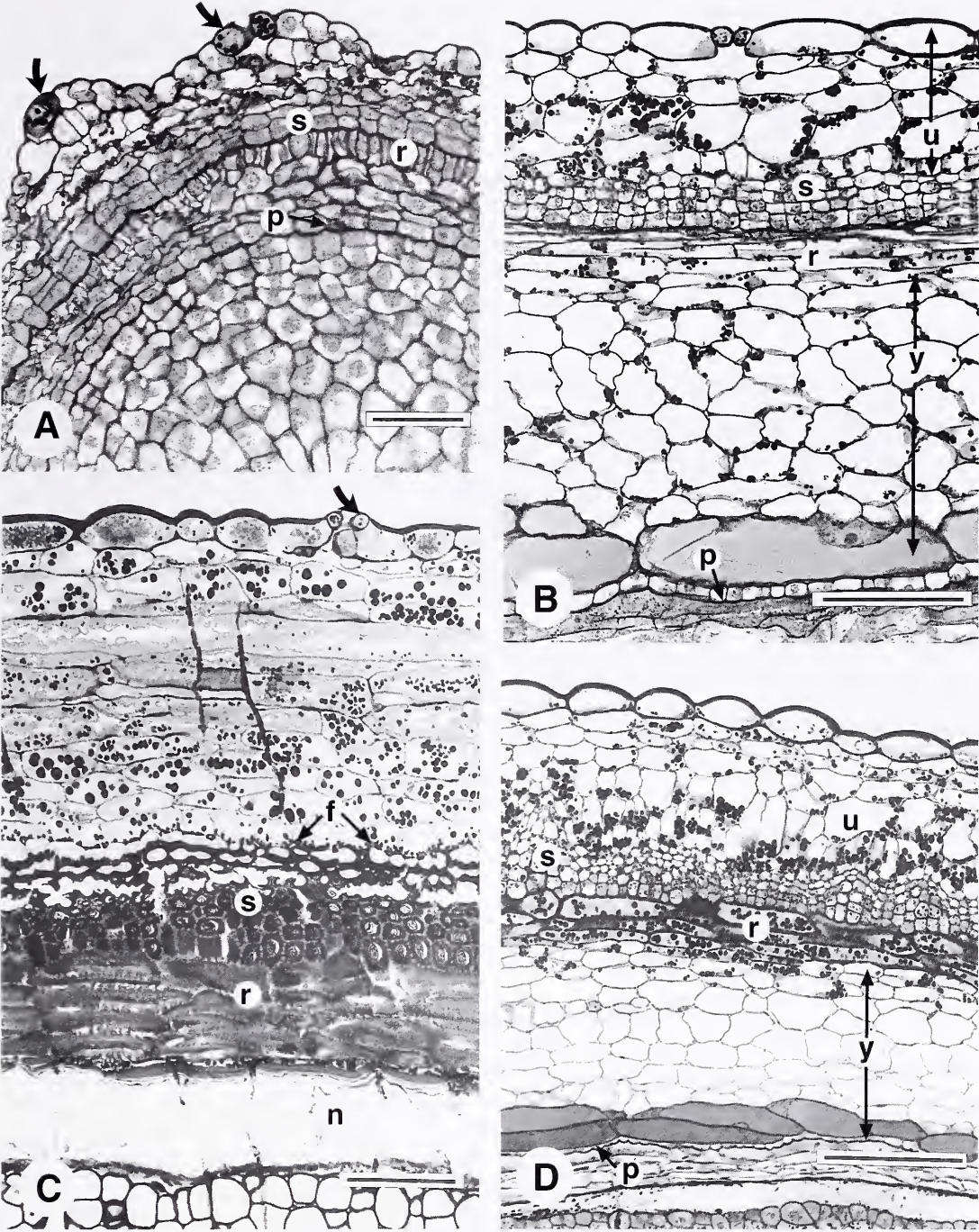


FIGURE 3.—Development and structure of seed coat in *Ceratiosicyos*. A, t/s young seed coat just after fertilization; B, l/s seed coat during first stages of pro-embryo formation; C, l/s mature seed coat of dispersed seed; D, l/s seed coat during maturation of fibrous exotegmen. Curved arrows indicate position of stomata; n, nucellus cell remains; p, inner epidermis of tegmen; r, outer epidermis of tegmen with anticlinal divisions; s, derivatives of inner epidermis of testa; u, sarcotesta; y, mesophyll of tegmen. Scale bars: A, 50  $\mu$ m; B, C, 100  $\mu$ m; D, 200  $\mu$ m.

parenchymatous, sarcotestal tissue that, especially in this area, contains large numbers of starch grains (Figure 4A). Stomata, not seen in the outer epidermis of the ovule, were found at regular intervals in the developing (Figure 3A, B) and mature (Figure 3C) epidermis of the sarcotesta.

When the seeds are dispersed, the cells of the innermost layer of the sarcotesta have developed small, fibrillar protuberances on their inner tangential walls (Figures 3C, 4A, B). The fringe-like wall ingrowths are strongly PAS-positive and also stain dark blue with toluidine blue. The fringe layer possibly represents a layer of transfer



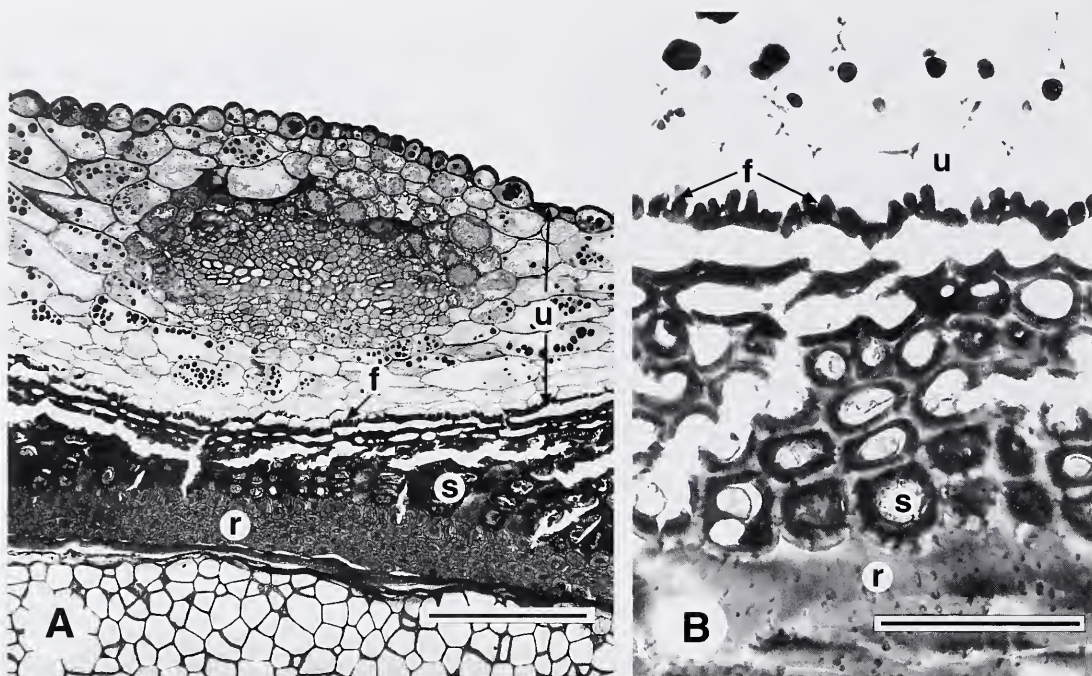


FIGURE 4.—Development and structure of seed coat of *Ceratiosicyos* (continued): A, raphe and underlying seed coat layers in a median t/s of seed; B, t/s fringe layer and adjacent cell layers seen at higher magnification than in Figure 3C. f, fringe layer; r, fibres of exotegmen; s, derivatives of inner epidermis of testa; u, sarcotesta. Scale bars: A, 200  $\mu$ m; B, 50  $\mu$ m.

cells (Gunning & Pate 1969), often found in reproductive structures for the short-distance transport of solutes (Johri & Ambegaokar 1984: 29, fig. 1.13A–F).

#### Contribution of the inner integument (tegmen) to the seed coat

After fertilization the conspicuously elongated outer epidermal cells of the inner integument (Figure 1A) initially divide anticlinally to form a single layer of dense-

ly packed, radially elongated meristematic cells (Figure 3A). While the first divisions of the pro-embryo are taking place, these meristematic cells of the tegmen divide periclinally once or twice to form three to four layers of cells that are stretched in a direction parallel to the longitudinal axis of the seed (Figure 3B). At this stage the cuticle between the developing endotesta and exotegmen starts to disappear, but in longitudinal sections of immature seeds the boundary between the two layers is clear because of the difference in the orientation of the cells (Figure 3B, D). When the seed reaches its final size, the

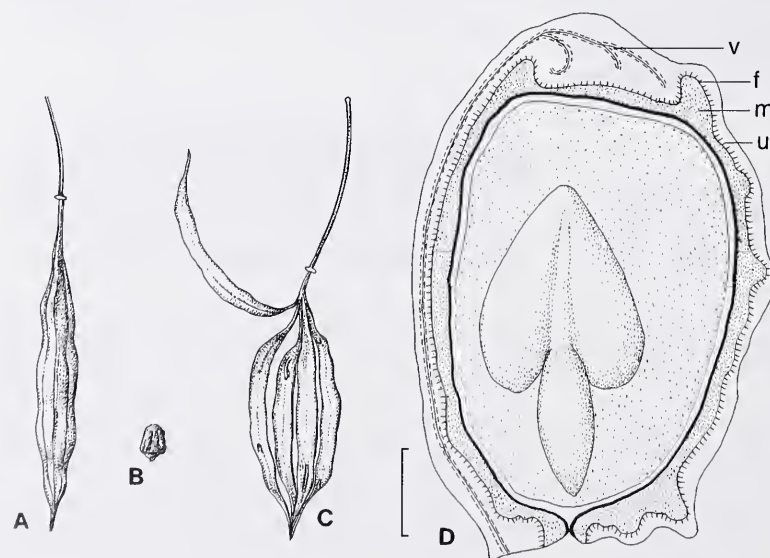


FIGURE 5.—Fruit and seed of *Ceratiosicyos*. A, mature, 5-valved capsule,  $\times 0.8$ ; B, dispersed seed,  $\times 0.8$ ; C, dehiscent fruit, showing funicles of varying lengths left on the placentae,  $\times 0.8$ ; D, l/s seed. f, fringe layer; m, mechanical layers; u, sarcotesta; v, vascular bundle branching in chalaza. Scale bar: 1 mm. Artist: G. Condry.



exotegmic cells contain many starch grains and the outer elements have started maturing into fibres (Figure 3D). At seed dispersal stage the fibres have thick, lignified walls with simple pits and contain no starch (Figures 3D; 4A, B).

The mesophyll and inner epidermis of the tegmen do not play a significant role in the structure of the mature seed coat. The thin-walled mesophyll tissue initially shows divisions in various planes so that the layers increase in number (Figure 3B). The innermost layer of mesophyll cells becomes conspicuous by their large size and darkly staining properties (Figure 3B, D). At first, the inner epidermis of the tegmen keeps pace with the growth of the seed by dividing anticlinally so that a layer of small, densely packed cells is formed (Figure 3B). Eventually, when the seeds are dispersed, all layers inside the exotegmic fibres are obliterated and a structureless pellicle remains between the fibres and the flattened cells of the nucellar tissue (Figures 3C; 4A).

Macromorphology of the fruit and seed and tests for myrmecochory

Mature fruit consists of 50–90 mm long, 5-valved capsules (Figure 5A, C) that are thin-walled and light green at seed dispersal stage. Five to twelve stalked seeds are arranged in a single row, sometimes packed close to one another in the locule. When the valves split open (not very forcefully), the seeds break off, leaving their funicles of various lengths attached to the centre of the valves (Figure 5C). Seeds are ovoid to short-cylindrical, 6.0–6.5

mm long (Figure 5B), dark green to brown and covered with a thin, succulent and translucent sarcotesta. The seed surface becomes tuberculate when the sarcotesta dries out, reflecting the projections formed by the underlying mechanical layers (Figure 5D). At seed dispersal, the axile embryo (sensu Martin 1946: 520) is of medium size (i.e. it occupies about three-quarters of the length of the endosperm). It lies straight in the seed, has thin, spatulate cotyledons and a well-formed radicle (Figure 5D).

Tests for myrmecochory were negative. If ant–seed interactions are not species specific as claimed by Slingsby & Bond (1981) and found by Steyn *et al.* (in press), our results suggest that *Ceratosicyos* seeds are not dispersed by ants.

DISCUSSION

Differences between *Ceratosicyos* and *Acharia* and *Guthriea*

A comparison of ovule and seed characters in *Ceratosicyos* with those of *Guthriea* and *Acharia* (Table 1) shows that the three genera are fundamentally very similar in characters usually regarded as of taxonomic importance (see No. 1, 2, 8–12, 14, 16 & 17). The structure of the integuments is also comparable to a large degree, although *Ceratosicyos* lacks the peculiar zigzag micropyle (see No. 5) that characterizes ovules and seeds of *Guthriea* and *Acharia*. The short outer integument in the *Ceratosicyos* ovule possibly does not denote an important structural difference with the other two genera, because this integument overtops the inner after fertiliza-

TABLE 1.—A comparison of ovule and seed characters in Achariaceae

No.	Character	<i>Ceratosicyos</i>	<i>Guthriea</i> and <i>Acharia</i>
1.	Ovule position and number	Parietal, 7–15 ovules on 5 placentas.	Parietal, 15–35 ovules on five placentas ( <i>Guthriea</i> ); 4 ovules on 4 placentas ( <i>Acharia</i> ).
2.	Ovule type	Anatropous, bitegmic, crassinucellate.	Anatropous, bitegmic, crassinucellate.
3.	Outer integument	Multi-layered, as long as inner in ovule, overtops inner after fertilization to form exostome, not lobed distally.	Multi-layered, longer than inner in ovule and seed to form exostome, lobed at distal rim.
4.	Inner integument	Multi-layered, outer epidermal cells conspicuously long.	Multi-layered, outer epidermal cells conspicuously long.
5.	Micropyle canal	Straight, formed by inner integument in ovule, both integuments in seed.	Zigzag, formed by both integuments in ovule and seed.
6.	Raphe	Not pronounced.	Pronounced to form a ridge.
7.	Funicle	Variable in length, often long in ovule and seed.	Practically absent, ovules and seed sessile.
8.	Nucellus cap formation	Epidermis divides periclinally to add to parietal nucellus.	Epidermis divides periclinally to add to parietal nucellus.
9.	Embryo sac	Bisporic, 8-nucleate, <i>Allium</i> Type.	Bisporic, 8-nucleate, <i>Allium</i> Type.
10.	Seed type	Anatropous, sarcotestal, endospermous.	Anatropous, sarcotestal, endospermous.
11.	Seed size	Medium, 6.0–6.7 mm long.	Medium, 5–6 mm long.
12.	Embryo type	<i>Penaea</i> variation of Asterad Type, epiphysis present in quadrant stage.	<i>Penaea</i> variation of Asterad Type, epiphysis present in quadrant stage.
13.	Embryo size	Medium, ± 4 mm.	Small, < 2 mm.
14.	Presence of stomata	In outer epidermis of sarcotesta.	In outer epidermis of sarcotesta.
15.	Presence of trichomes	Absent.	Present as unicellular hairs on seed surface.
16.	Sarcotestal structure	Comprises uni-layered outer epidermis and chlorenchymatous mesophyll of outer integument, raphe and chalaza; innermost cells form fringe layer.	Comprises bi-layered outer epidermis with hairs, hypodermis and chlorenchymatous mesophyll of outer integument, raphe and chalaza; innermost cells form fringe layer.
17.	Mechanical layers in seed	Endotestal sclereids + longitudinal exotegmic fibres.	Endotestal sclereids + longitudinal exotegmic fibres.
18.	Chalazal seed lid	Absent.	Present.
19.	Dispersal mechanism	Autochory, elaiosome absent.	Autochory + myrmecochory, elaiosome present.

tion. The inner integument of *Ceratosicyos* bulges into the micropyle canal (Figure 2A). The bulging cells might have been mistaken for a nucellar beak by Dahlgren & Van Wyk (1988). The present investigation also showed that the mechanical seed coat layer in *Ceratosicyos* is, like those of the other two genera, of dual origin (endotestal-exotegmic) and not purely exotegmic as previously reported (Dahlgren & Van Wyk 1988).

Many of the differences between *Ceratosicyos* and the other two genera can possibly be attributed to specific adaptations for seed dispersal and germination (see No. 6, 7, 13, 15, 18 & 19). *Ceratosicyos* is not myrmecorous, the ovule therefore lacks the pronounced raphe that, in *Acharia* and *Guthriea*, eventually forms a ridge-like part of the sarcotestal elaiosome (see No. 6 & 19). The presence of unicellular hairs on the seed surface of *Guthriea* and *Acharia* (see No. 15) possibly also relates to myrmecochory, since openings left by broken-off trichome bases would allow ant-attracting substances to rapidly reach the seed surface (Steyn *et al.* in press).

Instead of a pronounced raphe, ovules and seeds of *Ceratosicyos* might have developed long funicles as an adaptation to seed dispersal (see No. 7). By varying the lengths of the funicles, the seeds can be manipulated into a single, vertical row in the narrow, elongated locule. This arrangement may be necessary for rapid splitting of the fruit by distributing pressure on the valves evenly along the length of the locule. In the two diplochorous (autochorous + myrmecochorous) genera (see No. 19) the seeds are sessile in the short-cylindrical capsules and pressure on the valves is applied by the swollen elaiosomes. Also, the capsules remain within the covering of persistent corolla tubes to protect developing seeds with their soft elaiosomes (Steyn *et al.* in press). *Ceratosicyos* is autochorous; its seeds need less protection and developing capsules rapidly outgrow the protective covering of the corolla tubes.

Seed size in genera of the Achariaceae does not differ significantly, but *Ceratosicyos* has a much larger embryo than the other two genera (see No. 11 & 13). We propose that the small embryo has been the causal factor for the formation of the unique seed lid in the other two genera. This device would allow water and air to enter the seed through the unsclerified cells in the rim of the lid during the slow maturation (12 weeks) of the embryo in the hydrated seed (Steyn *et al.* in press). The much larger embryo of *Ceratosicyos* possibly did not require such an adaptation.

Martin (1946) reasoned that smallness in embryos, as compared to size of the endosperm, is representative of a primitive state in seeds of angiosperms, and, conversely, that embryos which become well developed before dormancy, reflect a higher evolutionary rank. For dicotyledons, Corner (1976: 48) also regarded small embryos as primitive and considered simplification through loss of structures or cell layers as an indication of an advanced state in seeds. However, considered on its own, it is usually difficult, if not impossible, to tell which of the two embryo states—small or large—is the more primitive for a particular taxon. One reason for this difficulty is that embryo (and seed) size, like so many other characters,

are subject to homoplasy (parallelism, convergence and character state reversals). Unfortunately homoplasy is rampant among seed plants, thus considerably limiting the reliability of outgroup comparisons to establish polarity (Cronquist 1988). Compared to the other members of the family, *Ceratosicyos* shows a notable trend towards simplification of the seed through the loss of several cell layers and structures, e.g. trichomes, a bi-layered testa epidermis, a hypodermis, a crystal-containing layer inside the fringe layer, perisperm and the reduction of the chalazal region with seed lid. These reductions, together with the larger embryo, may indicate that *Ceratosicyos* is more advanced than *Guthriea* and *Acharia*. On the other hand, indications are that Kiggelariaceae may well be the sister group of Achariaceae (see further on). Both *Kiggelaria africana* and *Ceratosicyos laevis* share a medium-sized embryo and rather unspecialized seed coat, states that may be the plesiomorphic ones in Achariaceae. Relatively small embryos and a rather elaborate seed coat occur in *Acharia tragodes* and *Guthriea capensis*, both having specialized myrmecochorous seeds. Therefore *Ceratosicyos laevis*, with its lianaceous habit and mesic forest habitat, could just as well be the more primitive member of the family. *Acharia tragodes* (semi-woody shrublet) is confined to the xerophytic thicket vegetation of the Eastern Cape, with *Guthriea capensis* (rosulate herb) confined to temperate grassland and karroid vegetation at high altitude.

#### *Achariaceae versus families in Malpighiales*

A detailed comparison of ovule and seed characters in Achariaceae and the 36 families placed in Malpighiales (including many families traditionally placed in Violales) by Savolainen *et al.* (2000), is hampered by a lack of comparable data for many of the families (Davis 1966; Johri *et al.* 1992; Nandi *et al.* 1998). Achariaceae seem generally well placed in Malpighiales and fit in comfortably among those families previously regarded as part of Violales *sensu* Dahlgren (1980). Similarities include bitegmic, anatropous, crassinucellate ovules, parietal nucellus partly formed by nucellar epidermis derivatives, both integuments participating in formation of micropyle canal, nuclear endosperm becoming copious in the seed and a medium-sized to large embryo lying straight in the seed.

Some of the characters observed in Achariaceae are rare for Malpighiales, namely a bisporic *Allium* Type embryo sac, suspensorless Asterad Type embryos, protective seed layers containing endotestal sclereids and exotegmic fibres, and a sarcotesta. A number of characters shared by *Guthriea* and *Acharia*, such as the zigzag micropyle, distally lobed outer integument, perisperm and small embryo is also uncommon for the order. A zigzag micropyle and Asterad embryos conforming to the *Penaea* variation only occur in Violaceae (Davis 1966), while lobed integuments and perisperm are found in Scyphostegiaceae (Van Heel 1976; Johri *et al.* 1992) and sarcotestal seeds in Passiflorales (Nandi *et al.* 1998).

A possible phylogenetic link between Achariaceae and Flacourtiaceae (tribe Pangieae, particularly *Kiggelaria africana*) was first suggested by the breeding behaviour of a butterfly. Several butterflies in the sub-



tribe Acraeina (subfamily Acraeinae, tribe Acraeini), including the common garden acraea (*Acraea horta*), utilize as larval food plants, members of a closely knit group of plant families traditionally classified in the order Violales (notably Achariaceae, Flacourtiaceae, Passifloraceae and Turneraceae), all containing a unique group of toxic compounds known as cyclopentenoid cyanogenic glucosides (Seigler 1975; Dahlgren 1980; Cronquist 1981; Takhtajan 1997; Kroon 1999). In their natural habitat larvae of *Acraea horta* feed mainly on *Kiggelaria africana*, a species containing gynocardin as major cyanogenic glucoside (Jaroszewski & Olafsdottir 1987; Raubenheimer & Elsworth 1988). The larvae selectively sequester and store some of the gynocardin, which are passed on to all other stages in the life cycle, supplemented by apparent self-synthesis (Raubenheimer 1987, 1989). Accumulation of this toxin is believed to render the insects unpalatable to predators. Previously gynocardin has been isolated from the seed of *Gynocardia odorata* R.Br., another member of the tribe Pangieae (Coburn & Long 1966). When live plants of *Ceratisicyos laevis* and *Guthriea capensis* were introduced into the botanical garden at the University of Pretoria in the mid-1980s, both were immediately selected by *Acraea horta* for egg deposition; larvae emerged and butterflies were raised (Dahlgren & Van Wyk 1988). This observation led to a chemical study of *Ceratisicyos laevis*, the first of its kind on a member of the Achariaceae, resulting in the identification of gynocardin as one of the principal cyanogenic glucosides in this species (Jensen & Nielsen 1986); its presence in *Guthriea capensis* is suspected.

Based on evidence from molecular biology, Chase *et al.* (1996) also suggested a linkage between the herbaceous Achariaceae and the woody tribe Pangieae. This tribe included amongst others, *Gynocardia* R.Br., *Hydnocarpus* Gaertn., *Kiggelaria* L., *Pangium* Reinw. and *Trichadenia* Thwaites (Lemke 1988). In the circumscription of Soltis *et al.* (2000), Kiggelariaceae include *Pangium*, *Hydnocarpus*, and *Kiggelaria*. Our results show that Achariaceae agree closely with the latter two genera as far as seed development and seed coat structure are concerned. Van Heel (1979) found the seeds of *Hydnocarpus* and *Kiggelaria* sarcotestal with undulating endotestal-exotegmic mechanical layers, a dominant endotestal layer of sclereids, an outer integument that is initially short, but overtops the inner during seed formation and a cuticle that disappears early so that the dual nature of the protective layer is masked and the erroneous impression given that the seeds are pachychalazal. These characters are so similar to the characters we found in Achariaceae that they can be regarded as strong support for a linkage between Achariaceae and Kiggelariaceae.

In *Kiggelaria* the embryo is of medium size, as found in *Ceratisicyos*. It is perhaps noteworthy that seeds with a small embryo, a fleshy raphe and a conspicuous notched cuticle between the tegmen and nucellus as reported for *Guthriea* (Steyn *et al.* 2001) also occur in *Berberidopsis* Hook.f. (Van Heel 1979). This taxon, previously also included in the Flacourtiaceae (Lemke 1988), is currently regarded as a relict with an unclear taxonomic position (Savolainen *et al.* 2000).

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# The grasslands and wetlands of the Sekhukhuneland Centre of Plant Endemism, South Africa

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**Keywords:** biodiversity, Braun-Blanquet, conservation, endemism, grassland, Mpumalanga, norite, phytosociology, Sekhukhuneland, syntaxonomy

## ABSTRACT

A hierarchical classification, description, and ecological and floristic interpretations are presented on the vegetation types of the grasslands and wetlands of the Sekhukhuneland Centre of Plant Endemism. Relevés were compiled in 74 stratified random plots. A TWINSPLAN classification, refined by Braun-Blanquet procedures, revealed eight associations, 11 subassociations and four variants. Many new syntaxa are described and ecologically interpreted. For each syntaxon, the species richness, endemism and conservation status was determined. The floristic and habitat information, proposed classification, general description and vegetation key are provided to aid future identification of conservation areas, land use planning and further research. An ordination (DECORANA), based on floristic data, confirmed the relationships that exist between plant communities and associated habitats and environmental gradients. Much of the plant community diversity and distribution can be ascribed to a heterogeneous environment, predominantly determined by soil moisture.

## INTRODUCTION

Several phytosociological studies have been conducted on vegetation types along the northeastern escarpment of the Northern Province and Mpumalanga (Bloem 1988; Deall *et al.* 1989; Matthews *et al.* 1992a, b; Burgoyne *et al.* 2000). However, the vegetation of some areas still remains to be investigated and described, both on reconnaissance level and in more detail. The undulating norite hills in the Roossenekal-Tonteldoos region is an area with very limited information on the vegetation. It is located in the southern portion of the Sekhukhuneland Centre of Plant Endemism (SCPE) (Van Wyk & Van Wyk 1997; Van Wyk & Smith 2001), and comprises the Roossenekal Subcentre of Endemism (Siebert 1998). The Roossenekal Subcentre is known for its many plant endemics, the distributions of which correlate with the diversity in geological substrate in the region (Siebert 1998; Siebert *et al.* 2001).

Various grassland and wetland vegetation types that show a floristic affinity and relationships with the Roossenekal Subcentre (Siebert 1998), have previously been described from the adjacent Steenkampsberg (Bloem 1988; Burgoyne 1995), Witbank Nature Reserve (Smit *et al.* 1997), and the Great Dyke of Zimbabwe (Werger *et al.* 1978). Acocks (1988) mapped the vegetation of the Roossenekal Subcentre as two veld types, namely North-eastern Sandy Highveld (57) and Bankenveld (61). A broad-scale classification of the same region's vegetation was given by Low & Rebelo (1996), who recognize three vegetation types, namely Mixed Bushveld (18), Moist Sandy Highveld Grassland (38) and North-eastern Mountain Grassland (43). These veld/vegetation types are closely associated with seasonal fires (Edwards 1984).

Only Acocks (1988) accurately mapped the high-altitude outcrops of norite (Leolo Mountains) in the northern region of the SCPE as grassland, namely North-eastern Sandy Highveld (57). Geologically and floristically the Leolo Mountains is similar to the Roossenekal Subcentre, and is treated as part of the study area covered in this paper (Siebert 1998). However, the vegetation classification of the entire Sekhukhuneland Centre needs further attention, as comparatively little is known about its plant communities, floristic diversity and the relationship between distribution patterns of plants and the clayey soils derived from the ultramafic norite.

This paper forms part of a comprehensive vegetation and floristic survey of the Sekhukhuneland area. It is envisaged that the identification, classification and description of the various vegetation units (syntaxa) will contribute to the knowledge of the plant diversity and biological intricacies of the region. This paper provides ecological and floristic data of the region's grasslands and wetlands, and the associated habitats, by characterizing and interpreting the vegetation units. Classification is basic to the formulation of a management policy and for proper land use planning. An assessment of the plant species richness, endemism and Red Data List taxa in the plant communities of the study area is supplied as baseline data to apply in future conservation actions in the region and application in ecosystem management. An adequate database of natural features and other land uses is essential for effective land use management and implementation (Kent & Ballard 1988; Bedward *et al.* 1992; Rhoads & Thompson 1992).

In a broad overview of the vegetation types of the SCPE, Siebert *et al.* (2002) recognized six major vegetation units. The vegetation units described in this paper cover the *Themeda triandra*–*Senecio microglossus* Cool Moist Grassland and the *Fuirena pubescens*–*Schoenoplectus corymbosus* Wetland Vegetation, the two major vegetation types of the relatively moist Roossenekal Subcentre. A vegetation key is presented to aid with the identification of the proposed syntaxa in the study area.

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## STUDY AREA

The study area is situated in northern Mpumalanga between latitude  $25^{\circ} 00'$  and  $25^{\circ} 20'$  S and longitude  $29^{\circ} 50'$  and  $30^{\circ} 05'$  E (southern part of the SCPE) and southern Northern Province between latitude  $24^{\circ} 30'$  and  $24^{\circ} 50'$  S and longitude  $30^{\circ} 00'$  and  $30^{\circ} 05'$  E (Leolo Mountains) (Figure 1). The area covers  $\pm 1\,500\text{ km}^2$  and comprises a homogeneous geology (Visser *et al.* 1989), with a heterogeneous physiography (Land Type Survey Staff 1987). The Sekhukhuneland Centre is more or less restricted to the Rustenburg Layered Suite of the Bushveld Complex (Siebert *et al.* 2001). The area dealt with in this paper lies on the Upper and Main Zones of the Rustenburg Layered Suite and is mainly underlain by concentric belts of norite, and to a lesser degree outcrops of ferrogabbro (Visser *et al.* 1989). This norite stratum extends north-south and rises to form the Leolo Mountains (1 700 m asl). The lower reaches of the mountainous areas are characterized by many small outcrops of magnetite.

The Roossenekal Subcentre is defined as the grassland areas in and adjacent to the sixteenth degree grid 2529 BB

and also includes the outlier Leolo Mountains in the Northern Province. Thirty-four of the Sekhukhuneland endemics/near-endemic plant species which are largely restricted to these areas were recorded during the study (Siebert 1998). The area forms an ecotone between the Mixed Bushveld (18) and the North-eastern Sandy Highveld (57) Veld Types (Acocks 1988), but it is probably more representative of Bankenveld (61), than any of the aforementioned veld types. The valleys have a sub-tropical climate with little or no frost in winter, whereas in the mountains, conditions become more temperate with increasing altitude. In this region of undulating rocky hills, the vegetation is characterized by scattered woodlands in sheltered habitats of footslopes and in valleys, and grassland with bush clumps covering the exposed plateaus, hill slopes and valleys. The difference in altitude between the two most extreme locations is  $\pm 500\text{ m}$  (1 700 m asl on the Leolo Mountains to 1 200 m asl where the Klip River cuts through the hills near Roossenekal).

The study area lies in the summer rainfall region, with an average annual precipitation of about 700 mm (South African Weather Bureau 1998). Local rainfall patterns

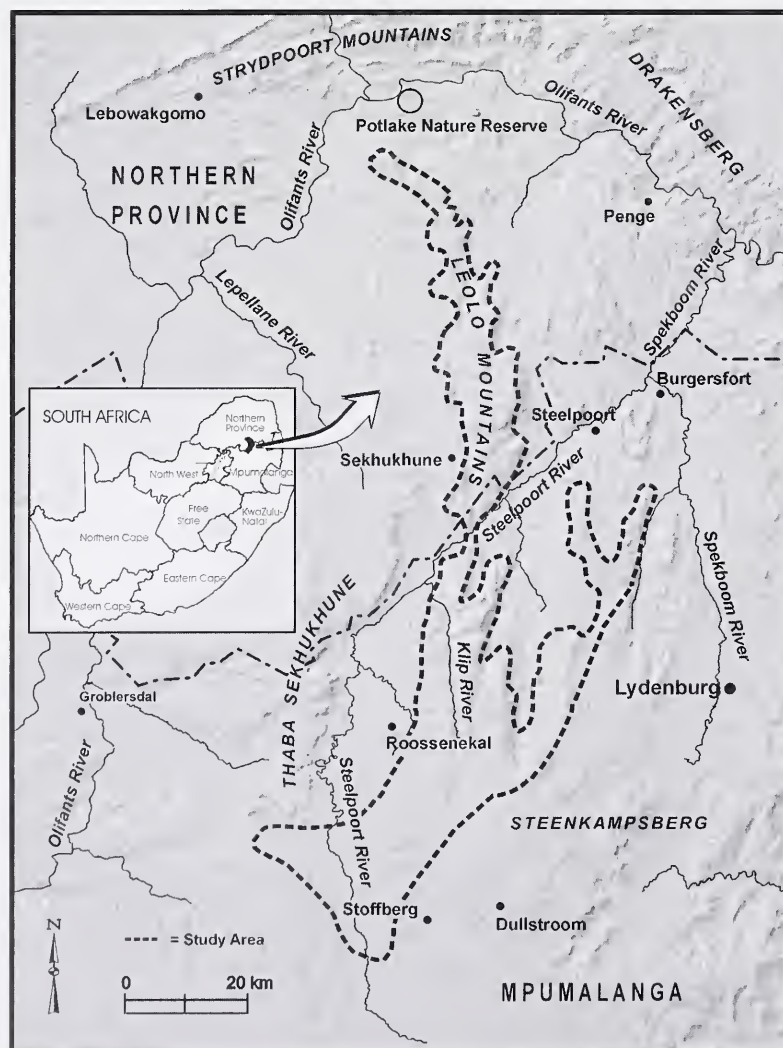


FIGURE 1.—Location of the grasslands of the study area in the Northern Province and Mpumalanga, South Africa.



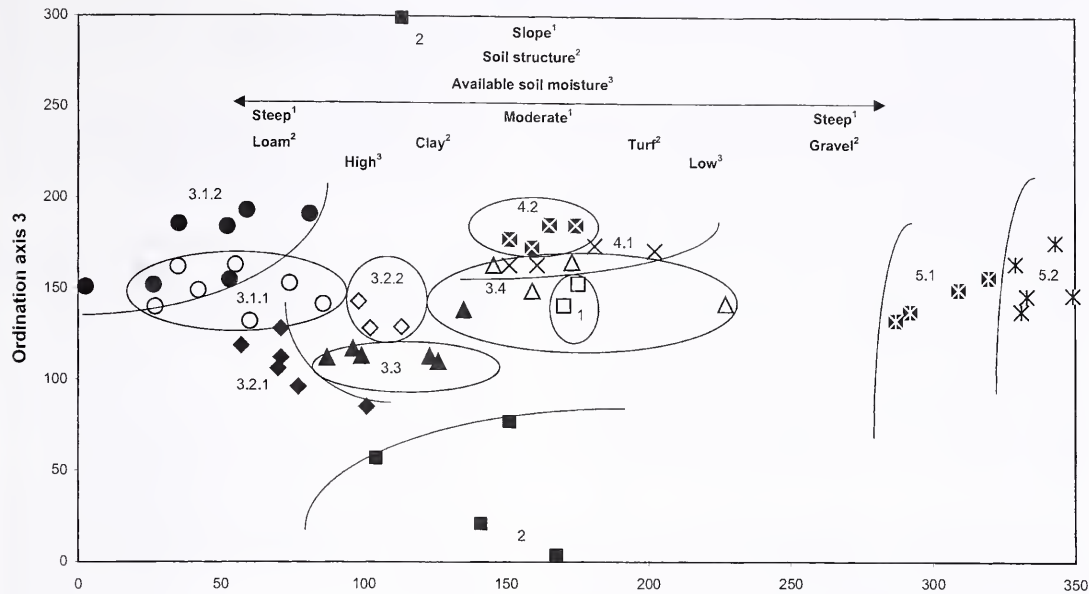


FIGURE 2.—Relative positions of all the relevés along the second and third axis of the ordination of the grassland vegetation of the Sekhukhuneland Centre of Plant Endemism. Numbers correspond with those of syntaxa in Table 1a and in the text.

are strongly influenced by the area’s topography and altitude (Siebert 1998), varying from 721 mm in the east, to 607 mm per annum in the west; 710 mm in the south, to 702 mm in the north (Erasmus 1985). Daily average temperature ranges from a minimum of 2.8°C in winter to a maximum of 25.9°C in summer, with an average annual temperature of 16.2°C (South African Weather Bureau 1998). Temperatures vary at different localities within the area, also correlating strongly with physiographic regions, being higher in low-lying valleys and lower on high-lying plateaus (Buckle 1996). However, minimum temperatures of below freezing point are rare, even in the high-lying areas.

METHODS

A first approximation of a vegetation classification, based on the total floristic data set of 415 stratified random sample plots was obtained by the application of the Two-Way Indicator Species Analysis (TWINSPAN) (Hill 1979a). The first step of an objective multivariate classification identified six major vegetation types for the Sekhukhuneland Centre (Siebert *et al.* 2002). These results were then used to subdivide the data set into five phytosociological tables. One of these tables, representing two major vegetation types, namely grasslands and wetlands, was again subjected to TWINSPAN. Using Braun-Blanquet procedures in the MEGATAB computer program (Hennekens 1996a), we further refined the resultant classification.

Floristic and habitat data of the grasslands and wetlands were derived from 74 relevés. Stratification was based on terrain type, aspect and vegetation structure. To standardize the plot size and to counter the bias of different scale (Jonsson & Moen 1998), plots sampled in the grassland were fixed at 100 m². Within each sample plot, all species were recorded and a cover-abundance value was assigned

to each species according to the Braun-Blanquet scale (Mueller-Dombois & Ellenberg 1974). Plant species names conform to those of Retief & Herman (1997), and the practice followed in the H.G.W.J. Schweickerdt Herbarium (PRU), University of Pretoria. Terminology to describe vegetation structure follows Edwards (1983). Environmental data recorded for each sample plot include terrain type (Land Type Survey Staff 1987), aspect, slope, geology (Visser *et al.* 1989), soil type (MacVicar *et al.* 1991) and rockiness of soil surface. Longitude and latitude readings were also recorded for each sample plot using a GPS. All relevé data are stored in the TURBOVEG database (Hennekens 1996b), managed by the Department of Botany, University of Pretoria (Mucina *et al.* 2000). Syntaxa names are given in accordance with the Code of Phytosociological Nomenclature (Weber *et al.* 2000).

The ordination algorithm Detrended Correspondence Analysis (DECORANA) (Hill 1979b) (Figure 2) was applied to confirm gradients in vegetation and the relationship between these plant communities and the physical environment.

To facilitate the identification of areas of high conservation potential, the alpha diversities of the different plant communities were calculated. The alpha diversity (plant species richness) is defined as the number of species per unit area within a homogeneous community or the total number of species per community (Whittaker 1977). A 100 m² sample plot was taken as the unit area within a homogeneous community.

The geographical distribution of all the taxa was verified at the National Herbarium (PRE), Pretoria, to identify any taxa endemic/near-endemic to the region (Siebert 1998). All taxa were also checked against the Red Data List of southern African plants (Hilton-Taylor 1996) to determine their conservation status.

## RESULTS

## Classification of vegetation

The analysis resulted in the identification of 17 plant communities, ordered as eight associations, 11 subassociations and four variants (Table 1a, b). These units were subsequently hierarchically classified. Since the study area covered by these communities lies in the climatologically uniform moist and cool southern region of the SCPE (Siebert 1998), no major macroclimatic variation plays a role in local differentiation of the plant communities. The major plant communities relate to soil character, rockiness and terrain type, with aspect and slope also playing minor roles. Communities were not always distinctive in the field. This might be attributed to the homogeneity of grassland physiognomy and the heterogeneity of the environmental factors, which resulted in a complex mosaic distribution pattern of habitats and associated vegetation.

The hierarchical classification of the vegetation reinforces the correlation between habitat and plant communities (Figures 2, 3). The distribution of the SCPE endemic/near-endemic and Red Data List plant taxa among various plant communities is listed in Table 2. A summary of selected floristic and habitat attributes for each plant community is supplied in Table 3.

The *Themeda triandra*–*Senecio microglossus* Cool Moist Grassland (Siebert *et al.* 2002) is interpreted as belonging to the proposed *Tristachya leucothrix*–*Trachypogon spicatus* Class (Du Preez & Bredenkamp 1991). The *Fuirena pubescens*–*Schoenoplectus corymbosus* Wetlands (Siebert *et al.* 2002) is interpreted as part of the *Miscanthus junceus*–*Schoenoplectus corymbosus* Community (Bloem 1988), proposed here as an alliance. The grassland and wetland plant communities of the Roosenekal Subcentre are classified as follows:

**I. *Tristachya leucothrix*–*Trachypogon spicatus* Class of moist mountain slopes and plateaus (Du Preez & Bredenkamp 1991) [= *Themeda triandra*–*Senecio microglossus* Cool Moist Grassland (Siebert *et al.* 2002)]**

1. *Heliclyso splendidi*–*Tristachyetum leucothricis* Association
2. *Zantedeschia pentlandi*–*Aloetum castaneae* Association
3. *Brachiario serratae*–*Melhanietum randii* Association
  - 3.1. *Brachiario serratae*–*Melhanietum randii* *heliclysetosum rugulosi* Subassociation
    - 3.1.1. *Digitaria eriantha* Variant
    - 3.1.2. *Alloteropsis semialata* Variant
  - 3.2. *Brachiario serratae*–*Melhanietum randii* *argyrobictosum transvaalense* Subassociation
    - 3.2.1. *Koeleria capensis* Variant
    - 3.2.2. *Berkheya seminivea* Variant
- 3.3. *Brachiario serratae*–*Melhanietum randii* *gnidiotosum capitatae* Subassociation
- 3.4. *Brachiario serratae*–*Melhanietum randii* *setarietosum nigrirostris* Subassociation
4. *Elionuro mutici*–*Trachypogonetum spicati* Association
  - 4.1. *Elionuro mutici*–*Trachypogonetum spicati* *bewsietosum biflorae* Subassociation

- 4.2. *Elionuro mutici*–*Trachypogonetum spicati* *acacietosum tortilis* Subassociation
5. *Jamesbrittenio macranthae*–*Loudetietum simplicis* Association
  - 5.1. *Jamesbrittenio macranthae*–*Loudetietum simplicis* *coubretetosum hereroense* Subassociation
  - 5.2. *Jamesbrittenio macranthae*–*Loudetietum simplicis* *eucleetosum linearis* Subassociation

**II. *Miscanthus junceus*–*Schoenoplectus corymbosus* Alliance of streams (Bloem 1988) [= *Fuirena pubescens*–*Schoenoplectus corymbosus* Wetland Vegetation (Siebert *et al.* 2002)]**

6. *Fuireno pubescentis*–*Schoenetum nigricantis* Association
  - 6.1. *Fuireno pubescentis*–*Schoenetum nigricantis* *triraphietosum audropogonoidis* Subassociation
  - 6.2. *Fuireno pubescentis*–*Schoenetum nigricantis* *pycnostachietosum reticulatae* Subassociation
  - 6.3. *Fuireno pubescentis*–*Schoenetum nigricantis* *bulbostylietosum hispidulae* Subassociation
7. *Audropogono eucomusae*–*Fimbristyletum ferrugineae* Association

**III. Drakensberg escarpment wetlands (Hilliard & Burt 1987)**

8. *Limosello maioris*–*Ranunculetum meyeri* Association

## Description of plant communities

The *Themeda triandra*–*Senecio microglossus* Cool Moist Grassland and scattered *Fuirena pubescens*–*Schoenoplectus corymbosus* Wetland Vegetation are predominantly restricted to the valleys, slopes and plateaus of undulating norite hills (Siebert *et al.* 2002). Surface rocks are common and abundant in many of the communities, with soil clay percentages varying from 25% to more than 50%. The vegetation can be classified into hermland and grassland (Edwards 1983). An important feature of the region is the fact that the mountain and hill ranges have a north-south orientation; therefore the grassland communities are mostly restricted to eastern and western aspects, crests and valleys. Grasslands have been a long-standing component of the Afri-montane vegetation mosaic (Meadows & Linder 1989; Matthews *et al.* 1993), and are therefore seen as primary vegetation. Plant communities of the grasslands and wetlands recognized in the SCPE are classified as follows:

**I. *Tristachya leucothrix*–*Trachypogon spicatus* Class (Du Preez & Bredenkamp 1991)**

1. *Heliclyso splendidi*–*Tristachyetum leucothricis* ass. nova hoc loco

Nomenclatural type: relevé 408 (holotypus).

*Environmental data:* a medium altitude grassland, forms a transition from low to high altitude (1 700 m asl). It lies in a rather moist region (> 600 mm/annum), mostly restricted to the summit of the Leolo Mountains on norite. The habitat is a gentle undulating plateau (1–5°) with a general east-west aspect (Table 3). The dominant





TABLE 1a.—Phytosociological table of grasslands of SekhukhuneLand Centre of Plant Endemism (cont.)

	Relève	4 4	1 3	2 2 3	3 3 3 3 3	1 1	5 6 9	1 1 2 8	1 1	3 4 4 4	3 4 4 4	1 1	1 1	3 4 4 4	3 4 6 0 8
0 0	9 0 1	2 2 3 9 7 7 1	5 5 1 1 2 1 2	2 3 6 8 1 9 3	8 0 8 9 1 9 6 3 0	3 .	3 .	1 1 2 8	1 1	3 4 4 4	3 4 4 4	1 1	1 1	3 4 4 4	3 4 6 0 8
8 9	2 3 2 0 2	5 6 1 4 6 7 4	3 .	3 .	3 .	3 .	3 .	1 1 2 8	1 1	3 4 4 4	3 4 4 4	1 1	1 1	3 4 4 4	3 4 6 0 8
1	2	1 .	1 .	2 .	2 .	2 .	2 .	1 1 2 8	1 1	3 4 4 4	3 4 4 4	1 1	1 1	3 4 4 4	3 4 6 0 8
	Sub-association	1	1	2	1	1	1	1 1 2 8	1 1	3 4 4 4	3 4 4 4	1 1	1 1	3 4 4 4	3 4 6 0 8
	Variant							1 1 2 8	1 1	3 4 4 4	3 4 4 4	1 1	1 1	3 4 4 4	3 4 6 0 8
	Species group E (cont.)							1 1 2 8	1 1	3 4 4 4	3 4 4 4	1 1	1 1	3 4 4 4	3 4 6 0 8
	<i>Sporobolus pectinatus</i>							1 1 2 8	1 1	3 4 4 4	3 4 4 4	1 1	1 1	3 4 4 4	3 4 6 0 8
	<i>Helichrysum albidinatum</i>							1 1 2 8	1 1	3 4 4 4	3 4 4 4	1 1	1 1	3 4 4 4	3 4 6 0 8
	Species group F							1 1 2 8	1 1	3 4 4 4	3 4 4 4	1 1	1 1	3 4 4 4	3 4 6 0 8
	<i>Helichrysum ruginosum</i>							1 1 2 8	1 1	3 4 4 4	3 4 4 4	1 1	1 1	3 4 4 4	3 4 6 0 8
	<i>Pinipetella affra</i>							1 1 2 8	1 1	3 4 4 4	3 4 4 4	1 1	1 1	3 4 4 4	3 4 6 0 8
	<i>Senecio carinatus</i>							1 1 2 8	1 1	3 4 4 4	3 4 4 4	1 1	1 1	3 4 4 4	3 4 6 0 8
	<i>Tephrosia elongata</i>							1 1 2 8	1 1	3 4 4 4	3 4 4 4	1 1	1 1	3 4 4 4	3 4 6 0 8
	<i>Triadachya biseriata</i>							1 1 2 8	1 1	3 4 4 4	3 4 4 4	1 1	1 1	3 4 4 4	3 4 6 0 8
	<i>Acalypha angustata</i>							1 1 2 8	1 1	3 4 4 4	3 4 4 4	1 1	1 1	3 4 4 4	3 4 6 0 8
	<i>Panicum natalense</i>							1 1 2 8	1 1	3 4 4 4	3 4 4 4	1 1	1 1	3 4 4 4	3 4 6 0 8
	<i>Leonotis acynifolia</i>							1 1 2 8	1 1	3 4 4 4	3 4 4 4	1 1	1 1	3 4 4 4	3 4 6 0 8
	Species group G							1 1 2 8	1 1	3 4 4 4	3 4 4 4	1 1	1 1	3 4 4 4	3 4 6 0 8
	<i>Berkheya semivivacea</i>							1 1 2 8	1 1	3 4 4 4	3 4 4 4	1 1	1 1	3 4 4 4	3 4 6 0 8
	<i>Drimys atropurpurea</i>							1 1 2 8	1 1	3 4 4 4	3 4 4 4	1 1	1 1	3 4 4 4	3 4 6 0 8
	<i>Helichrysum cephaloidesum</i>							1 1 2 8	1 1	3 4 4 4	3 4 4 4	1 1	1 1	3 4 4 4	3 4 6 0 8
	<i>Pachycarpus transvaalensis</i>							1 1 2 8	1 1	3 4 4 4	3 4 4 4	1 1	1 1	3 4 4 4	3 4 6 0 8
	<i>Thesium magalismontionum</i>							1 1 2 8	1 1	3 4 4 4	3 4 4 4	1 1	1 1	3 4 4 4	3 4 6 0 8
	<i>Helichrysum pilosellum</i>							1 1 2 8	1 1	3 4 4 4	3 4 4 4	1 1	1 1	3 4 4 4	3 4 6 0 8
	<i>Pearsonia obovata</i>							1 1 2 8	1 1	3 4 4 4	3 4 4 4	1 1	1 1	3 4 4 4	3 4 6 0 8
	Species group H							1 1 2 8	1 1	3 4 4 4	3 4 4 4	1 1	1 1	3 4 4 4	3 4 6 0 8
	<i>Edulia villasa</i>							1 1 2 8	1 1	3 4 4 4	3 4 4 4	1 1	1 1	3 4 4 4	3 4 6 0 8
	<i>Ipomoea obscura</i>							1 1 2 8	1 1	3 4 4 4	3 4 4 4	1 1	1 1	3 4 4 4	3 4 6 0 8
	<i>Crabbea hirsuta</i>							1 1 2 8	1 1	3 4 4 4	3 4 4 4	1 1	1 1	3 4 4 4	3 4 6 0 8
	<i>Koeleria capensis</i>							1 1 2 8	1 1	3 4 4 4	3 4 4 4	1 1	1 1	3 4 4 4	3 4 6 0 8
	Species group I							1 1 2 8	1 1	3 4 4 4	3 4 4 4	1 1	1 1	3 4 4 4	3 4 6 0 8
	<i>Eragrostis chloromelos</i>							1 1 2 8	1 1	3 4 4 4	3 4 4 4	1 1	1 1	3 4 4 4	3 4 6 0 8
	<i>Thunbergia arripetifolia</i>							1 1 2 8	1 1	3 4 4 4	3 4 4 4	1 1	1 1	3 4 4 4	3 4 6 0 8
	<i>Haplocarpho scaposa</i>							1 1 2 8	1 1	3 4 4 4	3 4 4 4	1 1	1 1	3 4 4 4	3 4 6 0 8
	<i>Helichrysum setosum</i>							1 1 2 8	1 1	3 4 4 4	3 4 4 4	1 1	1 1	3 4 4 4	3 4 6 0 8
	<i>Schistatephium crotaefolium</i>							1 1 2 8	1 1	3 4 4 4	3 4 4 4	1 1	1 1	3 4 4 4	3 4 6 0 8
	Species group J							1 1 2 8	1 1	3 4 4 4	3 4 4 4	1 1	1 1	3 4 4 4	3 4 6 0 8
	<i>Vernonia notolensis</i>							1 1 2 8	1 1	3 4 4 4	3 4 4 4	1 1	1 1	3 4 4 4	3 4 6 0 8
	<i>Rhus discolor</i>							1 1 2 8	1 1	3 4 4 4	3 4 4 4	1 1	1 1	3 4 4 4	3 4 6 0 8
	<i>Argyrolobium transvaalense</i>							1 1 2 8	1 1	3 4 4 4	3 4 4 4	1 1	1 1	3 4 4 4	3 4 6 0 8
	<i>Vernonia golpii</i>							1 1 2 8	1 1	3 4 4 4	3 4 4 4	1 1	1 1	3 4 4 4	3 4 6 0 8
	<i>Bacium obovatum</i>							1 1 2 8	1 1	3 4 4 4	3 4 4 4	1 1	1 1	3 4 4 4	3 4 6 0 8
	<i>Canvolvulus sagittatus</i>							1 1 2 8	1 1	3 4 4 4	3 4 4 4	1 1	1 1	3 4 4 4	3 4 6 0 8
	<i>Borleria ovata</i>							1 1 2 8	1 1	3 4 4 4	3 4 4 4	1 1	1 1	3 4 4 4	3 4 6 0 8
	<i>Gerbera ambigua</i>							1 1 2 8	1 1	3 4 4 4	3 4 4 4	1 1	1 1	3 4 4 4	3 4 6 0 8
	<i>Ipomoea crossipes</i>							1 1 2 8	1 1	3 4 4 4	3 4 4 4	1 1	1 1	3 4 4 4	3 4 6 0 8
	Species group K							1 1 2 8	1 1	3 4 4 4	3 4 4 4	1 1	1 1	3 4 4 4	3 4 6 0 8
	<i>Aloe costarico</i>							1 1 2 8	1 1	3 4 4 4	3 4 4 4	1 1	1 1	3 4 4 4	3 4 6 0 8
	<i>Kudratis foetidissimo</i>							1 1 2 8	1 1	3 4 4 4	3 4 4 4	1 1	1 1	3 4 4 4	3 4 6 0 8
	<i>Eragrostis rocnoso</i>							1 1 2 8	1 1	3 4 4 4	3 4 4 4	1 1	1 1	3 4 4 4	3 4 6 0 8
	<i>Ladacourto revoluto</i>							1 1 2 8	1 1	3 4 4 4	3 4 4 4	1 1	1 1	3 4 4 4	3 4 6 0 8
	<i>Cyphostemma sp. A (AW 13589)</i>							1 1 2 8	1 1	3 4 4 4	3 4 4 4	1 1	1 1	3 4 4 4	3 4 6 0 8
	<i>Alteplaco seifero</i>							1 1 2 8	1 1	3 4 4 4	3 4 4 4	1 1	1 1	3 4 4 4	3 4 6 0 8
	<i>Tetraxlo wilmsii</i>							1 1 2 8	1 1	3 4 4 4	3 4 4 4	1 1	1 1	3 4 4 4	3 4 6 0 8
	<i>Pellaea calomelanos</i>							1 1 2 8	1 1	3 4 4 4	3 4 4 4	1 1	1 1	3 4 4 4	3 4 6 0 8



TABLE 1a.—Phytosociological table of grasslands of Sekhukhuneland Centre of Plant Endemism (cont.)

[illegible]







TABLE 1b.—Phytosociological table of wetlands of Sekhukhuneland Centre of Plant Endemism

Relevé	3	1	2	1	1	1	2	4	4
	1 7 2	2 2 0	3 3 6 7	4 8 9 8	1 1				
	5 1 3 2	2 3 2	4 6 6 5	1 1 2 1	0 5				
Association	6	6	6	7	8				
Sub-association	1	2	3						
Species group AA									
<i>Schoenus nigricans</i>	A A 1 +	3 A	1 1 A R						
<i>Chironia purpurascens</i>	+ + + +	+ + +	+ + +						
<i>Hypoxis argentea</i>	R R	R R	R R						
<i>Hyparrhenia tamba</i>	+ R 1	R	1 +						
<i>Equisetum ramosissimum</i>	+ +	R	+ R						
Species group AB									
<i>Tripharis andropogonoides</i>	A 1 A								
<i>Juncus punctatius</i>	A 1	R							
<i>Digitaria graveolens</i>	+ 1 + R			R					
<i>Nuxia gracilis</i>	+ + 1		R						
<i>Adiantum capillus-veneris</i>	R + +								
<i>Coleocitella setifera</i>	R 1 1								
Species group AC									
<i>Cyperus sexangularis</i>	1 +	1 +							
<i>Kyllinga erecta</i>	+ + R	+ +							
<i>Berula erecta</i>	+ R +	+ R +							
Species group AD									
<i>Bulbostylis hispidula</i>			A 1 +						1 1
<i>Alepis amaryllacea</i>			+ + R						+ +
<i>Botriochloa insculpta</i>			+ + +						+ +
<i>Microchloa caffra</i>			+ R						+ +
Species group AE									
<i>Pycnostachys reticulata</i>		1 1 1	+ R						
<i>Mariscus congestus</i>		1 + +	+ + A						
<i>Leonotis leonurus</i>		+ R +	+ +						
<i>Lippia javanica</i>		R +	R + R +	R					
<i>Senecio gerrardii</i>		1 1	1 +						
<i>Monopsis decipiens</i>		+ R	R +						
<i>Pteris buchananii</i>		+ +	R +						
Species group AF									
<i>Polygonum meisnerianum</i>				1 R					
<i>Mariscus sumatrensis</i>				+ +					
<i>Conyza bonariensis</i>				+ +					
<i>Cyperus marginatus</i>				+ +					
<i>Flaveria bidentis</i>				R R					
<i>Mariscus rehmannianus</i>				1 1 R					
<i>Salix mucronata</i>				+ + 1					
<i>Eragrostis gummiflua</i>				R 1 +					
Species group AG									
<i>Phragmites australis</i>		1 1 3		A 3 1 3					
<i>Fimbristylis ferruginea</i>	R	+ +	R	+ 1 +					
<i>Helictes cooperi</i>		+ R +		R R					
<i>Cyperus sphaerospermus</i>		R +		1 + +					
<i>Gomphocarpus fruticosus</i>		R 1		+ R					
<i>Senecio gregatus</i>		R +		+ R					

Relevé	3	1	2	1	1	2	4	4
	1 7 2	2 2 0	3 3 6 7	4 8 9 8	1 1			
	5 1 3 2	2 3 2	4 6 6 5	1 1 2 1	0 5			
Association	6	6	6	7	8			
Sub-association	1	2	3					
Species group AH								
<i>Ischaemum fasciculatum</i>		R	+ + R	R +				
<i>Kyllinga alba</i>			R + +	R + + R				
<i>Hemarthra altissima</i>			+ + R	R + +				
Species group AI								
<i>Andropogon eucamus</i>	1 1 +	1 +	1 + + 1	1 R + 1				
<i>Fuirena pubescens</i>	A 1 + +	1 3	B A A 1	+ R 1				
<i>Artemisia afra</i>	1 + +	+ +	+ + + +	+ 1				
<i>Cliffortia nitidula</i>	1 1 +	R	1 + R 1	R + +				
<i>Verbena brasiliensis</i>	+ R +	+ +	+ R +	1 + +				
<i>Miscanthus junceus</i>	+ + +	A A	R 1 1	1 + 1				
<i>Pulicaria scabra</i>	+ +	R	R + +	R + +				
<i>Imperata cylindrica</i>	+ + +	+ +	+ + +	+ + +				
<i>Rhus leptodictya</i>	+ R +	R	R + +	R + + R				
<i>Plantago lanceolata</i>	+ R +	+ R +	+ + +	R + +				
<i>Verbena bonariensis</i>	+ + +	+ R	R R +	R + +				
<i>Typha capensis</i>	+ R +	R + 1	1 + +	R 1				
Species group AJ								
<i>Ranunculus meyeri</i>								1 1
<i>Anagallis huttonii</i>								+ +
<i>Limosella major</i>								+ +
<i>Ranunculus multifidus</i>								+ +
<i>Sporobolus centrifugus</i>								+ +
Species group AK								
<i>Schoenoplectus corymbosus</i>	+ A + +	1 B A	R + +	+ R 1 + +				
<i>Gomphostigma virgatum</i>	+ + +	R	R + +	1 + + R				
Species group shared with Table 1a								
Species group Y								
<i>Eragrostis capensis</i>		R	+ +	+ +	R			
<i>Eragrostis curvula</i>	R R	R	R					
<i>Hyparrhenia lirta</i>		R		+ 1				
<i>Senecio microglossus</i>	1 + +	+ +	+ +	R				
<i>Aristida bipartita</i>	+ + 1 R	R	R	R R R				
<i>Heteropogon contortus</i>	R R R		R + +	R R				
<i>Cymbopogon validus</i>	1 B + +	A 1 1	1 + +	+ + + +				
<i>Hyparrhenia filipendula</i>	R R	1 + +	1 + + 1	+ + R R				
<i>Scabiosa columbaria</i>	+ +	+ +	+ +	+ +				
<i>Lippia rehmannii</i>	+ +	R +	+ +	+ + +				
<i>Acacia karroo</i>	R + +	+ +	+ +	+ + R				
<i>Eucumis autumnalis</i>	R	R	R R	R R R				
<i>Chlorophytum fasciculatum</i>	+ + R							

soil type is the Mayo Form, a melanic A-horizon over a lithocutanic B-horizon. Rock size is 300–500 mm in diameter and rock cover 15–20%.

**Diagnostic and dominant/prominent taxa:** in the SCPE this association is characterized by species group A (Table 1a). *Euryops brevipapposus*, *Helichrysium splendidum* and *Vernonia myriantha* are the most prominent diagnostic species of this syntaxon. Other diagnostic species include the shrub *Buddleja saligna* and the herbaceous *Lotononis foliosa* and *Xerophyta viscosa*. There are no diagnostic grasses, but dominant species include *Eragrostis capensis*, *E. curvula* and *Tristachya leucothrix*. A prominent forb is *Pentanisia prunelloides*, while the shrub *Protea caffra* (endemic form) is conspicuously present.

**Floristic diversity:** this grassland community is unique for the SCPE and only a slight floristic affinity exists with other grassland types of the SCPE in species groups M and X (Table 1a). The average number of species per relevé is 30, and the total number of species recorded for the association is 40 (two relevés) (Table 3). Three plant taxa of conservation significance occur in this association (Table 2), namely the endemic form of *Protea caffra*, the endemic *Zantedeschia jucunda* that is

classified as Indeterminate in the Red Data List (also restricted to the association) and *Jamesbrittenia silenoides*, a taxon assessed as Vulnerable in KwaZulu-Natal.

2. *Zantedeschia pentlandi*–*Aloetum castaneae* ass. nova hoc loco

Nomenclatural type: relevé 100 (holotypus)

**Environmental data:** a short hermland on rocky flats, areas where bedrock is exposed at ground level. The plant community is associated with rock outcrops of norite, a rock type mined extensively as dimension stone in the region. It is situated on gentle slopes (0–5°) and with a very high surface rock cover of 50–70% (Table 3). Solid exposed rock sheets can cover areas of 25 m<sup>2</sup>. The dominant soil type is the Mispah Form, indicating very shallow soils over hard rocks, often restricted to crevices. The habitat is situated on the midslopes, scarps and crests of undulating hills.

**Diagnostic and dominant/prominent taxa:** characteristic species are represented by species group B (Table 1a). Diagnostic trees/shrubs of the association include *Apodytes dimidiata*, *Canthium suberosum*, *Halleria luci-*

TABLE 2.—Endemic/near-endemic and Red Data List plant taxa of grasslands and wetlands associated with Sekhukhuneland Centre of Plant Endemism

Taxon	Family	Syntaxon																
			2	3.1.1	3.1.2	3.2.1	3.2.2	3.3	3.4	4.1	4.2	5.1	5.2	6.1	6.2	6.3	7	8
<i>Acacia karroo</i> [form] (P4)	FABA	.	.	.	.	.	.	S+	.	.	S1	S1	.	.	S+	.	Sr	Sr
<i>Aloe castanea</i>	ASPH	.	#1	#+	#r	#r	.	#+	.	.	.	.	.	.	.	.	.	.
<i>Aneliema longirrhizum</i>	COMM	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
<i>Argyrobolium wilmsii</i>	FABA	.	.	.	#r	#r	#r	.	.	.	.	.	#+	.	.	.	.	.
<i>Asclepias</i> sp. (S27)	ASCL	.	Sc	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
<i>Berkheya densifolia</i>	ASTE	.	.	#r	.	.	.	.	.	.	.	.	.	.	.	.	.	.
<i>B. insignis</i> [form] (S257)	ASTE	.	.	S+	S+	S+	S+	S+	S1	S1	.	.	.	.	.	.	.	.
<i>Callilepis leptophylla</i>	ASTE	.	.	N+	N+	N+	N+	N+	N+	.	.	S+	S+	.	.	.	.	.
<i>Cyphostemma</i> sp. (W13389)	VITA	.	Sr	Sr	Sr	Sr	.	Sr	.	.	.	.	.	.	.	.	.	.
<i>Disa rhodantha</i>	ORCH	.	.	.	.	.	.	.	.	.	.	.	.	.	.	Kr	Kr	.
<i>Elephantorrhiza praetermissa</i>	FABA	.	KSr	.	.	.	.	.	.	.	.	KSr	KSr	.	.	.	.	.
<i>Euclea linearis</i> [form] (S937)	EBEN	.	.	.	.	.	.	.	.	.	.	.	#+	.	.	.	.	.
<i>Eucomis autumnalis</i> subsp. <i>clavata</i>	LILI	.	.	Nr	Nr	.	Nr	.	.	.	.	.	.	Nr	Nr	Nr	Nr	Nr
<i>E. montana</i>	LILI	.	Rr	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
<i>Gnidia caffra</i> [form] (W12975)	TILI	.	.	S+	Sr	Sr	S+	S+	S+	S+	S+	S+	S+	.	.	.	.	.
<i>Helichrysum albilanatum</i>	ASTE	.	.	#1	.	.	.	.	.	.	.	.	.	.	.	.	.	.
<i>H. uncinervium</i>	ASTE	.	.	.	.	.	.	.	.	.	.	#1	#1	.	.	.	.	.
<i>Hermannia antonii</i>	STER	.	.	.	#r	.	.	#+	#1	#r	.	.	.	.	.	.	.	.
<i>Ipomoea bathycolpos</i> var. <i>sinuatoindentata</i>	CONV	.	.	.	.	.	.	.	.	.	.	.	Sr	.	.	.	.	.
<i>Jamesbrittenia macrantha</i>	SCHR	.	.	.	.	.	.	.	.	.	.	Ks1	Ks1	.	.	.	.	.
<i>J. silenoides</i>	SCHR	.	Nr	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
<i>Jasminum quinatum</i>	OLEA	.	#r	.	.	.	.	.	.	.	#+	.	.	.	.	.	.	.
<i>Melhania randii</i>	STER	.	.	K#1	K#1	K#1	K#1	K#1	K#1	.	.	.	.	.	.	.	.	.
<i>Nuxia gracilis</i>	LOGA	.	.	.	.	.	.	.	.	.	.	.	.	K#1	.	K#+	.	.
<i>Pegolettia lanceolata</i>	ASTE	.	.	.	.	#r	.	#+	#r	.	.	.	.	.	.	.	.	.
<i>Polygala</i> sp. (S449)	POLY	.	.	.	.	.	.	.	.	.	.	.	S1	.	.	.	.	.
<i>Protea caffra</i> [form] (S1382)	PROT	S+	.	S1	S+	Sr	S+	.	S1	.	.	S1	S1	.	.	.	.	.
<i>Rhoicissus</i> sp. (S48)	VITA	.	.	S+	S+	S+	S1	S1	Sr	.	.	.	.	.	.	.	.	.
<i>Rhus keetii</i>	ANAC	.	.	.	.	.	.	.	.	.	.	.	#r	.	.	.	.	.
<i>R. rogersii</i>	ANAC	.	.	.	.	.	.	.	.	Nr	Nr	.	.	.	.	.	.	.
<i>R. tumulicola</i> var. <i>meuseana</i>	ANAC	.	.	.	.	.	.	.	.	#r	.	.	.	.	.	.	.	.
<i>R. wilmsii</i>	ANAC	.	K#+	K#+	K#+	K#r	K#r	K#r	K#r	.	.	K#1	K#1	.	.	.	.	.
<i>Rhynchosia nitens</i>	FABA	.	Kr	.	.	.	.	Kr	.	.	.	.	.	.	.	.	.	.
<i>Schizoglossum</i> sp. (S628)	ASCL	.	Sr	Sr	.	.	Sr	.	.	.	.	.	.	.	.	.	.	.
<i>Scilla natalensis</i>	LILI	.	Nr	Nr	N+	Nr	Nr	N+	N+	.	.	.	.	.	.	.	.	.
<i>Thesium gracilentum</i>	SANT	.	.	K+	K+	Kr	Kr	K+	K+	K+	K+	.	.	.	.	.	.	.
<i>T. multiramulosum</i>	SANT	.	.	.	.	.	.	.	.	.	#+	#+	#+	.	.	.	.	.
<i>Triaspis glaucophylla</i>	MALP	.	#+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
<i>Tristachya biseriata</i>	POAC	.	Kr	K+	K+	.	.	.	.	.	.	.	.	.	.	.	.	.
<i>Tulbaghia</i> sp. (S1304)	LILI	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	Sr
<i>Vitex obovata</i> subsp. <i>wilmsii</i>	VERB	.	#+	#+	#+	#+	#+	#+	#+	#+	#+	#+	#+	.	.	.	.	.
<i>Xerophyta retinervis</i> [form] (W13208)	VELL	.	Sr	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
<i>Zantedeschia jucunda</i>	ARAC	IS+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
<i>Z. pentlandii</i>	ARAC	.	R#+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
SCPE endemics		2	5	5	5	5	5	5	4	4	3	5	7	1	0	1	1	1
SCPE near-endemics		0	6	5	7	6	4	6	5	3	3	6	7	1	0	1	0	0
Red Data List		2	7	7	7	5	6	6	5	2	2	3	3	2	2	3	1	1
Restricted to syntaxon		2	5	1	1	0	0	0	0	1	0	1	4	0	0	0	0	1
Restricted to association		2	5	.	.	.	6	.	.	2	.	7	.	.	2	.	0	1
Total syntaxon		3	15	15	17	14	13	15	12	9	8	11	14	3	2	4	2	2
Total association		3	15	.	.	.	22	.	.	11	.	15	.	4	.	.	2	2

Endemism: S, endemic; #, near-endemic.  
Red Data List: 1, Indeterminate; K, Insufficiently Known; R, Rare; N, Not threatened in northern provinces of South Africa, but in other areas of southern Africa.  
Abundance in communities: 1, abundant; +, frequent; r, rare; ., absent.  
Collectors: P = P.S. Swartz; S = S.J. Siebert; W = A.E. van Wyk.  
Blocks represent community/syntaxon specific taxa.

*da* and *Olinia emarginata*. Diagnostic forbs are *Thesium burkei*, the succulents *Crassula sarcocaulis* and *Aloe pretoriensis*, and the geophytes *Boophone disticha* and *Zantedeschia pentlandii*. *Aristida junciformis* and *Cymbopogon excavatus* are the diagnostic grasses of this association. Prominent plants are the succulent *Aloe castanea*, the shrubby *Rhoicissus tridentata* and the grasses *Eragrostis pseudosclerantha*, *Themeda triandra* and *Tristachya leucothrix*.

**Floristic diversity:** this association exhibits a typical floristic relationship with other grasslands of the SCPE (Table 1a). The average number of species encountered per sample plot is 36, with 105 species the total number recorded for the association (five relevés) (Table 3). Fifteen taxa of conservation significance are present in the association (Table 2), five are SCPE endemics, six are SCPE near-endemics and seven are Red Data List taxa. This association has a high number of plant taxa with conservation status in the southern region of the SCPE. The association also has a high number of plant taxa with conservation status restricted to it, such as *Asclepias* sp. (Siebert 27) (endemic), *Eucomis montana*

(Rare), *Xerophyta retinervis* form (endemic) and *Zantedeschia pentlandii* (endemic, Rare).

3. *Brachiario serratae*–*Melhanietum randii* ass. nova hoc loco

Nomenclatural type: relevé 321 (holotypus).

**Environmental data:** short, dense grassland associated with plateaus or terraces on rocky undulating hills. The association is found on all aspects, on gentle to moderate slopes (5–15°) of footslopes, midslopes, scarps and crests (Table 3). Soils are characterized by a melanic A-horizon underlain by hard rock (Milkwood Form) or a soft carbonate horizon (Steendal Form). Rock cover is 15–75% and rock diameter 0.1–1 m (Table 3).

**Diagnostic and dominant/prominent taxa:** characteristic species of the association are represented by species group C (Table 1a). The dominant diagnostic forbs are *Callilepis leptophylla*, *Dicoma zeyheri*, *Gnidia capitata*, *Melhania randii* and *Vernonia oligocephala*. Woody species typical of the association include the geoxylic



TABLE 3.—Environmental factors and selected attributes associated with different plant communities

Factors/attributes	Syntaxa																
	1	2	3.1.1	3.1.2	3.2.1	3.2.2	3.3	3.4	4.1	4.2	5.1	5.2	6.1	6.2	6.3	7	8
Total no. species	40	105	112	130	119	95	109	77	84	65	70	72	51	42	52	52	24
No. relevés	2	5	7	7	6	3	6	4	4	4	4	5	4	3	4	4	2
Ave. no. spp. per relevé	30	36	47	51	48	50	46	44	46	41	39	33	28	27	25	27	20
No. endemics/near-endemics	2	11	10	12	11	9	11	9	7	6	11	14	2	0	2	1	1
No. Red Data List taxa	2	7	7	7	5	6	6	5	2	2	3	3	2	2	3	1	1
Topographic position*	C	C	CS	M	CM	CM	MF	F	F	V	F	F	M	M	CV	V	C
Slope (°)	1–3	1–5	5–9	3–7	3–15	5–15	5–9	3–5	3–5	1–3	7–9	5–7	5–7	0–1	0–1	3–5	0–1
Aspect	E	ESW	NESW	NESW	EW	EW	EW	EW	EW	EW	NS	NESW	-	-	-	-	-
Predominant soil type**	My	Ms	My	Mw	Mw/Sd	Mw/Sd	Mw	Ar	Sn	Ar	Ms	Ms	-	-	-	-	-
Rock cover percentage (%)	15–20	50–70	20–40	25–50	25–50	25–75	35–40	15–30	20–25	5–10	60–70	20–70	35–45	5–15	10–20	20–30	5–10
Average rock size (mm)	300–500	>1000	200–950	150–450	450–950	100–250	400–750	100–250	50–150	50–150	100–400	100–200	350–750	50–100	50–100	150–200	10–50

\* C, crest; S, scarp; M, midslope; F, footslope; V, valley.  
\*\* Ms, Mispah; Ar, Arcadia; Sn, Steendal; My, Mayo; Mw, Milkwood; Sd, Shortlands.

suffrutices *Elephantorrhiza elephantina* and *Rhus wilmsii*, and the small trees *Acacia caffra*, *Protea caffra* and *Vitex obovata* subsp. *wilmsii*. Other prominent forbs include *Clerodendrum triphyllum*, *Senecio latifolius* and *Tephrosia purpurea*. Prominent grasses for the association are *Andropogon chinensis*, *Brachiaria serrata*, *Setaria sphacelata*, *Themeda triandra*, *Trachypogon spicatus* and *Tristachya leucothrix*.

**Floristic diversity:** the average number of species encountered per sample plot in this association is 48, with the total number of plant species being a minimum of 119 taxa (29 relevés) (Table 3). There are 25 plant taxa of conservation value in the association, of which four are restricted to it. These include taxa such as the near-endemics, *Argyrobolus wilmsii* and *Pachycarpus transvaalensis* (Table 2). Red Data List taxa include *Callilepis leptophylla* (status is Rare in KwaZulu-Natal), *Melhanium randii* (status is Insufficiently Known in the northern provinces) and *Scilla natalensis* (status is Vulnerable in the Free State and KwaZulu-Natal). This association harbours the highest number of plant taxa with conservation status in the southern region of the SCPE and, together with plant community 2, the highest number of Red Data List taxa.

3.1. *Brachiario serratae*–*Melhanietum randii* *helichrysosetosum rugulosi* subass. nova hoc loco

Nomenclatural type: relevé 321 (holotypus).

**Environmental data:** short rocky grassland communities on clay soils such as Mayo and Milkwood Forms, occurs on midslopes, scarps and crests of undulating norite hills on slopes of 3–9° on all aspects. Rock cover is 20–50% with rock size of 0.15–1 m in diameter (Table 3).

**Diagnostic and dominant/prominent taxa:** species group F contains the diagnostic species for this subassociation, with the taxa *Helichrysium rugulosum*, *Pimpinella caffra* and *Tephrosia elongata* (Table 1a). Other characteristic species include the forbs *Acalypha punctata*, *Leonotis ocyimifolia* and *Senecio lygodes*, as well as the grasses *Panicum natalense* and *Tristachya biseriata*. Trees that are prominent are *Euclea crispa* and *Vitex obovata* subsp. *wilmsii*. Predominant grasses are *Themeda triandra* and *Tristachya leucothrix*.

**Floristic diversity:** a strong floristic affinity exists with all the subassociations of the association (Table 1a). The average number of species encountered per sample

plot in this subassociation is 49, with the total number of plant species being a minimum of 130 taxa (14 relevés) (Table 3). Two plant taxa of conservation value are restricted to the subassociation (Table 2).

3.1.1. *Digitaria eriantha* Variant

**Environmental data:** rocky grassland on shallow clay soils of moderately sloped hill scarps and crests (Table 3). Rock size is 600 mm in diameter and cover is 25% (Table 3).

**Diagnostic and dominant/prominent taxa:** diagnostic taxa include the forbs *Agapanthus inapertus*, *Berkheya densifolia*, *Cyanotis speciosa*, *Indigofera hedyantha*, *Monsonia attenuata* and *Tephrosia longipes* and the grass *Digitaria eriantha* (species group D; Table 1a). Other frequently occurring grasses are *Andropogon schirensis*, *Brachiaria serrata* and *Setaria sphacelata*.

**Floristic diversity:** a strong floristic similarity exists with plant community 3.2.1, probably due to the similarity in their rock size and cover (species group H; Table 1a & Table 3). Five SCPE endemics, five near-endemics and seven Red Data List taxa are found in this variant (Table 2). Of the 112 taxa recorded for the variant (seven relevés), only 15 are of conservation value (one is restricted to it). The average number of species encountered per sample plot is 47 (Table 3).

3.1.2. *Alloteropsis semialata* Variant

**Environmental data:** rocky grasslands on shallow clay soils occurring on relatively steep midslopes of hills. Rock cover is 35%, with rocks 350 mm in diameter (Table 3).

**Diagnostic and dominant/prominent taxa:** *Berkheya onopordifolia*, *Helichrysium albilanatum*, *H. nudifolium* and the succulent *Kalanchoe rotundifolia*, are the diagnostic forbs, with *Alloteropsis semialata* and *Sporobolus pectinatus* the diagnostic grasses species (species group E; Table 1a). Dominant dwarf shrubs are *Clusia pulchella* and *Rhus discolor*.

**Floristic diversity:** the community shares a floristic identity within various species groups (Table 1a). Five SCPE endemics, and seven near-endemics and seven Red Data List taxa are found in this variant (Table 2). It has 17 taxa of conservation value, the highest number for this paper, with only one taxon restricted to it. The average number of species recorded per sample plot is 51 (richest plant diversity of all the study area's grassland

communities), with a total number of 130 plant taxa (seven relevés) (Table 3).

### 3.2. *Brachiario serratae*–*Melhanietum randii* *argyrolobetosum transvaalense* subass. nova hoc loco

Nomenclatural type: relevé 8 (holotypus).

*Environmental data*: a relatively tall, rocky grassland of midslopes and crests of undulating norite hills, occurs on soils of the Milkwood and Steendal Forms. It lies on relatively steep, sloped areas (3–15°). Rock cover is 25–75%, with rock diameter 100–950 mm (Table 3).

*Diagnostic and dominant/prominent taxa*: diagnostic species for this vegetation type is *Berkheya seminivea* and *Drimiopsis atropurpurea*. This subassociation is characterized by group G (Table 1a). Prominent taxa that occur in this vegetation unit are the forbs *Acalypha punctata*, *Argyrolobium transvaalense*, *Barleria ovata*, *Pachycarpus transvaalensis*, *Rhynchosia spectabilis*, *Tephrosia purpurea* and *Vernonia natalensis*. Important grasses for this vegetation type are *Brachiaria serrata*, *Diheteropogon amplexens*, *Setaria sphacelata* and *Themeda triandra*. Prominent woody species include the geoxylic suffrutices *Elephantorrhiza elephantina* and *Rhus discolor*.

*Floristic diversity*: the community exhibits a strong floristic affinity with all the grasslands of the study area (Table 1a). The average number of species encountered per sample plot in this subassociation is 49, with the total number of plant species being a minimum of 119 taxa (nine relevés) (Table 3). No plant taxa of conservation value are restricted to it (Table 2).

#### 3.2.1. *Koeleria capensis* Variant

*Environmental data*: relatively tall rocky mountain grassland on east-west aspects of steep midslopes and crests occurs on shallow clay soils, is covered by  $\pm$  30% rock, with a relatively large rock diameter (on average 650 mm) (Table 3).

*Diagnostic and dominant/prominent taxa*: no diagnostic species occur in this variant. Character species include the prominent forbs *Crabbea hirsuta* and *Ipomoea obscura*, and prominent grasses are *Eulalia villosa* and *Koeleria capensis* (species group G; Table 1a). Other dominant plants include the geoxylic suffrutex *Rhus discolor* and the small tree *Euclea crispa*. Grass cover is dense and species rich.

*Floristic diversity*: a strong floristic similarity is shared with plant community 3.1.1, probably due to similarity in rock size and cover (species group H; Table 1a & Table 3). Of the 14 taxa of conservation value in this variant, five are SCPE endemics, six near-endemics and five Red Data List taxa (Table 2). The average number of species encountered per sample plot is 48, with a total of 119 plant species (6 relevés), the second richest plant diversity in the study area's grasslands (Table 3).

#### 3.2.2. *Berkheya seminivea* Variant

*Environmental data*: rocky grassland communities on shallow clays of moderate midslopes and crests that are situated on east-west aspects (Table 3). Average rock size is 200 mm and cover is 40% (Table 3).

*Diagnostic and dominant/prominent taxa*: there are no diagnostic species, but characteristic species for this variant include the forbs *Berkheya seminivea*, *Drimiopsis atropurpurea*, *Heliclysum cephaloideum* and *Thesium magalismontanum* the most frequent (species group G; Table 1a). Other important taxa are *Andropogon schirensis*, *Argyrolobium transvaalense*, *Eragrostis chloromelas* and *Rhynchosia spectabilis*.

*Floristic diversity*: this variant is floristically typical of its association, but is characterized by the absence of the sister variant's character species (species group H; Table 1a). Of its 13 taxa of conservation value, five are SCPE endemics, four near-endemics and six Red Data List taxa (Table 2). The average number of species encountered per sample plot is 50, with the total being 95 taxa (three relevés) (Table 3).

### 3.3. *Brachiario serratae*–*Melhanietum randii* *gnidiotosum capitatae* subass. nova hoc loco

Nomenclatural type: relevé 86 (holotypus).

*Environmental data*: rocky grassland communities on black clay soils. The habitat is found on footslopes and midslopes of undulating norite hills. The gentle slopes vary from 5–9°, with an east-west aspect the norm. Soils characteristic of these slopes is the Milkwood Form. Rock cover varies from 35–40% and rock size from 400–750 mm in diameter.

*Diagnostic and dominant/prominent taxa*: species group J contains the characteristic species for this subassociation, with prominent forbs such *Becium obovatum*, *Convolvulus sagittatus*, *Gerbera ambigua* and *Vernonia galpinii* (Table 1a). The forbs *Senecio microglossus* and *S. latifolius*, and the grasses *Themeda triandra* and *Tristachya leucothrix* are the most dominant in this subassociation. Other important taxa are the woody species *Elephantorrhiza elephantina* and *Euclea crispa*, succulents *Aloe castanea* and *A. greatheadii*, and grass species such as *Eragrostis superba*, *Setaria sphacelata*, *Sorghum bicolor* and *Tristachya rehmannii*.

*Floristic diversity*: a strong floristic affinity exists with certain plant communities of the association (species group J), but excludes plant communities 3.1.1 and 3.4 (Table 1a). The average number of species encountered per sample plot in this subassociation is 46, the total number of plant species being 109 (six relevés) (Table 3). Although 15 taxa with conservation value occur in this subassociation (Table 2), namely five SCPE endemics, six near-endemics and six Red Data List taxa, no plant taxa with conservation value are restricted to it.

### 3.4. *Brachiario serratae*–*Melhanietum randii* *setarietosum nigrirostris* subass. nova hoc loco

Nomenclatural type: relevé 64 (holotypus).

*Environmental data*: moist rocky mountain grassland on black turf soils lies on the lower part of gentle, sloped footslopes, 3–5°. It is found predominantly on soils of the Arcadia Form. Rock cover is  $\pm$  15–30%, rocks, with a relatively small average size of 100–250 mm in diameter (Table 3).

*Diagnostic and dominant/prominent taxa*: diagnostic species are represented by species group L (Table 1a).



Diagnostic forbs are *Lotononis adpressa* and *Scleria dieterlenii*, and the grass *Setaria nigrirostris*. No tree species are diagnostic, but *Protea caffra* is extremely prominent in this subassociation. Other important forbs are *Bulbostylis contexta*, *Lotononis macrosepala* and *Pegolettia lanceolata*. *Berkheya insignis*, *Hermannia antonii*, *Hypoxis rigidula*, *Melhania randii*, *Senecio microglossus* and *Thesium gracilentum* are prominent forbs. Prominent grasses of the subassociation are *Elionurus muticus* and *Eragrostis nindensis*. Grasses found frequently are *Brachiaria serrata*, *Diheteropogon amplexens*, *Themeda triandra*, *Trachypogon spicatus* and *Tristachya leucothrix*.

**Floristic diversity:** the subassociation shows its strong floristic affinity within association 3 in species groups C and M (Table 1a). More detailed future studies could suggest its upgrading to the level of association. The average number of species encountered per sample plot in this subassociation is 44, with 77 plant species the total number (four relevés) (Table 3). Twelve taxa with conservation value occur in this subassociation (Table 2), namely four SCPE endemics, five SCPE near-endemics and five Red Data List taxa. No plant taxa with conservation value are restricted to it.

#### 4. *Elionuro mutici*–*Trachypogonetum spicati* ass. nova hoc loco

Nomenclatural type: relevé 112 (holotypus).

**Environmental data:** this rocky mountain grassland occurs on deep black turf soils (500–750 mm) which lie on moderately sloped, lower footslopes and valley bottoms, 5–15°. It is found predominantly on vertic Arcadia and Steendal Forms. Rock cover is 10–40% and rocks have a small average size of 100–150 mm in diameter (Table 3).

**Diagnostic and dominant/prominent taxa:** diagnostic species are presented in species groups N (Table 1a) and are characterized by the small trees *Rhamnus prinoides* and *Rhus rogersii*, the grasses *Brachiaria eruciformis* and *Setaria incrassata*, and the forbs *Indigofera evansiana*, *Kohautia caespitosa* and *Striga elegans*. Forbs are abundant in the vegetation unit and prominent species include *Albuca setosa*, *Berkheya onopordifolia*, *Felicia muricata*, *Helichrysum albanatum*, *H. nudifolium*, *Justicia anagaloides*, *Kalanchoe rotundifolia* and *Rubia horrida*. Prominent grasses of the association are *Alloteropsis semialata* and *Sporobolus pectinatus*, and dominant grasses such as *Brachiaria serrata*, *Eragrostis chloromelas*, *Heteropogon contortus* and *Panicum natalense*.

**Floristic diversity:** the average number of species encountered per sample plot in this association is 44, with the total number of plant species being a minimum of 84 taxa (12 relevés) (Table 3). There are 11 plant taxa of conservation value in the association (Table 2), of which two are restricted to it, including *Rhus rogersii*, a shrub assessed as Insufficiently Known for Swaziland in the Red Data List.

#### 4.1. *Elionuro mutici*–*Trachypogonetum spicati bewsietosum biflorae* subass. nova hoc loco

Nomenclatural type: relevé 42 (holotypus).

**Environmental data:** moist, cool mountain grassland on turf soils, lies on gentle, sloped footslopes, 3–5°, restricted to deep Steendal soils. Rock cover is ± 20–25% and rocks have an average diameter of 50–150 mm (Table 2).

**Diagnostic and dominant/prominent taxa:** diagnostic species are represented by species group O (Table 1a). Only one woody species, the shrubby *Rhus tumulicola* var. *meuseana*, is diagnostic of the subassociation, with *Acacia karroo* being a dominant and extremely common tree. *Argyrobolus amplexicaule*, *Conyza podoccephala*, *Helichrysum* spp., *Rhynchosia albissima* and *Senecio* spp. are the diagnostic forbs. *Bewisia biflora* is the only diagnostic grass. Other prominent forbs include *Pearsonia grandifolia*, *Senecio microglossus* and *Striga elegans*. Dominant grasses include *Brachiaria eruciformis*, *B. serrata*, *Diheteropogon amplexens*, *Elionurus muticus* and *Themeda triandra*.

**Floristic diversity:** a floristic link with plant community 4.2 in species group N, indicates the relationship between these two subassociations on turf (Table 1a), although the environmental data differ to a great extent. The average number of species encountered per sample plot is 46. The total number for this subassociation is 84 (four relevés) (Table 3). One plant taxon with conservation value, the near-endemic *Rhus tumulicola* var. *meuseana*, is restricted to it. Nine taxa with conservation value occur in this subassociation and comprise four SCPE endemics, three near-endemics and two Red Data List taxa (Table 2).

#### 4.2. *Elionuro mutici*–*Trachypogonetum spicati acacietosum tortilis* subass. nova hoc loco

Nomenclatural type: relevé 112 (holotypus).

**Environmental data:** wooded grassland communities on black turf soils. These units occur in valley bottoms between undulating norite hills. The gentle slope varies from 1–3° and eastern or western aspects are predominant. Soil characteristic of these slopes is the Arcadia Form. Rock cover is 5–10% and rock diameter is 50–100 mm (Table 3).

**Diagnostic and dominant/prominent taxa:** species group P contains the diagnostic species for this association (Table 1a). Two trees are diagnostic for the association, namely *Acacia tortilis* and *Dichrostachys cinerea*. These taxa are often dominant in the *Panicum maximi*–*Acacietea tortilis* class (Winterbach *et al.* 2000), a class representing microphyllus savanna in the central Bushveld of South Africa. Diagnostic grasses for the subassociation are *Digitaria sanguinalis*, *Panicum deustum*, *P. maximum* and *Sporobolus fimbriatus*. The association is dominated by forbs such as *Chrysanthemoides monilifera*, *Indigostrum burkeanum*, *Jasminum quinatum* and *Kyphocarpa angustifolia*. Other prominent taxa include the woody species *Rhamnus prinoides* and *Acacia karroo*, the herbaceous species *Asparagus suaveolens*, *Berkheya insignis*, *Gnidia caffra* and *Senecio microglossus*, and the grasses *Cymbopogon validus*, *Dihetero-*



*pogon amplexens*, *Elionurus muticus*, *Hyparrhenia filipendula*, *Loudetia simplex*, *Setaria sphacelata* and *Themeda triandra*.

**Floristic diversity:** a floristic link exists with the more herbaceous plant community 4.1, in species group N (Table 1a), but a difference in vegetation structure is apparent. The average number of species encountered per sample plot is 41 (Table 3). The total number of plant species for this subassociation is 65 (four relevés). No plant taxa with conservation value are restricted to the community, although three SCPE endemics, three SCPE near-endemics and two Red Data List taxa were recorded.

#### 5. *Jamesbrittenio macranthae*–*Loudetietum simplicis* ass. nova hoc loco

Nomenclatural type: relevé 47 (holotypus).

**Environmental data:** wooded grassland associated with anomalous habitats (Siebert 1998) occurs on red clay and white loam soils of predominantly the Mispah Form that are characterized by serpentiniferous chemical compositions. It lies on moderate footslopes of 5–9° on all aspects of undulating hills. Rock cover is  $\pm$  20–70% and with large rocks 100–400 mm in diameter (Table 3).

**Diagnostic and dominant/prominent taxa:** characteristic species are represented by species group S (Table 1a). Herbs are diagnostic of this community, namely *Helichrysum uninervium*, *Jamesbrittenia macrantha*, *Lotononis wilmsii*, *Polygala hottentotta* and *Rhynchosia komatiensis*. *Elephantorrhiza praetermissa* is the characteristic woody species and *Aristida adscensionis* and *Melinis repens* the characteristic grasses. Prominent forbs are *Dicoma anomala*, *Gnidia caffra*, *Melhania prostrata* and *Thesium multiramulosum*. Grasses of importance include *Aristida congesta*, *Diheteropogon amplexens*, *Elionurus muticus*, *Eragrostis nindensis*, *Loudetia simplex*, *Themeda triandra* and *Tristachya leucothrix*. *Protea caffra* and *Vitex obovata* subsp. *wilmsii* are prominent trees and *Rhus wilmsii* is a prominent geoxylic suffrutex of the association.

**Floristic diversity:** the average number of species encountered per sample plot is 36, with the total number of plant species being a minimum of 72 taxa (nine relevés) (Table 3). Fifteen taxa of conservation value occur and the association (Table 2) has the highest number of taxa with conservation status restricted to it (seven), and includes plant species such as the near-endemics *Helichrysum uninervium* and *Lotononis wilmsii*, and the endemic and Red Data-listed *Jamesbrittenia macrantha*.

#### 5.1. *Jamesbrittenio macranthae*–*Loudetietum simplicis* *combretetosum hereroense* subass. nova hoc loco

Nomenclatural type: relevé 47 (holotypus).

**Environmental data:** wooded grassland of rocky footslopes with clay soils. It lies on moderate slopes of 7–9° on north-south aspects of rocky ridges of magnetite. Soils are predominantly the Mispah Form. Rock cover is  $\pm$  60–70% and large rocks, 100–400 mm in diameter (Table 3).

**Diagnostic and dominant/prominent taxa:** the diagnostic species are represented by species group T (Table 1a), and include one tree species, *Combretum hereroense*. The forbs *Aneilema longirrhizum*, *Chamaecrista comosa*, *Hemizygia petrensis*, *Ledebouria marginata*, *Lotononis calycina*, *Phyllanthus incurvus* and *Triumfetta sonderi* are diagnostic. The most important dominant grasses include *Loudetia simplex*, *Themeda triandra*, *Tristachya leucothrix* and *T. rehmannii*. Other dominant taxa include *Protea caffra*, *Rhus wilmsii* and *Senecio microglossus*.

**Floristic diversity:** the subassociation shows a floristic affinity with the turf grasslands of the Roossenekal Subcentre in species groups V and W (Table 1a). A specific link with the grasslands of the study area, which includes its sister subassociation, is indicated in species group X. The average number of species encountered per sample plot is 39, with the total number for this subassociation being 70 (four relevés) (Table 3). Five SCPE endemics, six near-endemics and three Red Data List taxa are found in this subassociation (Table 2). Of its 11 taxa of conservation value, only the near-endemic *Aneilema longirrhizum* is restricted to it.

#### 5.2. *Jamesbrittenio macranthae*–*Loudetietum simplicis* *eucleetosum linearis* subass. nova hoc loco

Nomenclatural type: relevé 106 (holotypus).

**Environmental data:** wooded, rocky grassland on white loam soils and is restricted to exposed norite surfaces. It lies on moderately sloped footslopes of 5–7° on all aspects. Soils are predominantly the Mispah Form. Rock cover is  $\pm$  20–70% and large rocks, 100–200 mm in diameter (Table 3).

**Diagnostic and dominant/prominent taxa:** species group U (Table 1a) represents the diagnostic species of the subassociation. The diagnostic grass species of the subassociation is *Andropogon chinensis*. Six forbs are diagnostic, namely *Indigofera tristoides*, *Ipomoea bathycolpos* var. *sinuatodentata*, *Jamesbrittenia burkeana*, *Phyllanthus glaucophyllus*, *Polygala* sp. nov. (Siebert 449) and *Seddera capensis*. *Euclea linearis* is the diagnostic woody species of the subassociation. Dominant plants in the community are the forbs *Dicoma anomala* and *Helichrysum uninervium*, and grasses *Aristida adscensionis*, *Diheteropogon amplexens* and *Elionurus muticus*. *Protea caffra*, *Rhus wilmsii* and *Vitex obovata* subsp. *wilmsii* are dominant woody species.

**Floristic diversity:** a slight floristic affinity is visible between this subassociation and plant communities 4.2 and 5.1 in species group V (Table 1a). The average number of species encountered per sample plot is 33, with the total number for this subassociation being 72 (five relevés) (Table 3). It is one of the syntaxa with the highest numbers of SCPE endemics and SCPE near-endemics. It also has three Red Data List taxa (Table 2). Of its 14 taxa of conservation value, four taxa, namely the SCPE near-endemics *Rhus keetii* and *Euclea linearis* (form), and the SCPE endemics *Ipomoea bathycolpos* var. *sinuatodentata* and *Polygala* sp. (Siebert 449), are restricted to it. This number is the second highest for any community in the Roossenekal Subcentre.

## II. *Miscanthus junceus*–*Schoenoplectus corymbosus* Alliance (Bloem 1988)

### 6. *Fuireno pubescentis*–*Schoenetum nigricantis* ass. nova hoc loco

Nomenclatural type: relevé 73 (holotypus).

*Environmental data:* within the Roossenekal and Leolo Subcentres, this association represents hygrophilous vegetation of mountain streams and seepage areas and occurs on wet sites where rocks of  $\pm 150$  mm diameter cover  $\pm 25\%$  of the soil surface. These areas have gentle slopes ( $3^\circ$ ) and the soils are typically clay on solid rock, with a sandy alluvial layer on the surface.

*Diagnostic and dominant/prominent taxa:* species group AA (Table 1b) contains the diagnostic species. Dense stands of the diagnostic sedge *Schoenus nigricans* and the diagnostic grass *Hyparrhenia tamba* dominate the vegetation. Other diagnostic forbs are *Chironia purpurascens*, *Equisetum ramosissimum* and *Hypoxis argentea*. Sedges such as *Fuirena pubescens* and *Schoenoplectus corymbosus* are also prominent, while *Andropogon eucomis*, *Cymbopogon validus*, *Hyparrhenia filipendula* and *Imperata cylindrica* are prominent grasses. *Acacia karroo* and *Rhus leptodictya* are the woody species that may occur in the association.

*Floristic diversity:* a strong floristic affinity with the wetland community 7 is indicated in species group AI and some relationships exist with the grasslands (species group Y) (Table 1b). The azonal wetland vegetation is not as rich in plant diversity as the grasslands. The average number of species encountered per sample plot is only 27, with the total number of plant species being a minimum of 52 taxa (11 relevés) (Table 3). There are, however, four taxa of conservation value that occur in this association (Table 2), and two taxa with conservation status restricted to it, namely the Red Data listed orchid *Disa rhodantha* (Insufficiently Known), and the shrub, *Nuxia gracilis* (Insufficiently Known).

#### 6.1. *Fuireno pubescentis*–*Schoenetum nigricantis* *triraphetosum andropogonoidis* subass. nova hoc loco

Nomenclatural type: relevé 73 (holotypus).

*Environmental data:* sparsely wooded, moist herbland and grassland along non-perennial mountain streams in rocky areas lying on gentle to moderate midslopes ( $5$ – $7^\circ$ ). Rock size 350–750 mm in diameter and rock cover is 35–45%.

*Diagnostic and dominant/prominent taxa:* species group AB (Table 1b) contains the diagnostic species for this subassociation, which include the woody species *Acacia karroo*, *Nuxia gracilis* and *Rhus leptodictya*. Diagnostic forbs are the fern *Adiantum capillus-veneris*, and the sedges *Coleochloa setifera*, *Dittrichia graveolens* and *Juncus punctatorius*. *Triraphis andropogonoides* is a diagnostic grass. Prominent forbs are the sedges *Fuirena pubescens*, *Schoenoplectus corymbosus* and *Schoenus nigricans*. *Andropogon eucomis*, *Aristida bipartita* and *Cymbopogon validus* are the most dominant grasses.

*Floristic diversity:* a notable relationship exists with plant community 6.2 in species group AC (Table 1b).

The average number of species encountered per sample plot is 28, with the total number for this subassociation being 51 (four relevés) (Table 3). The association has three taxa of conservation value, including one SCPE endemic, one SCPE near-endemic and two Red Data List taxa (Table 2).

#### 6.2. *Fuireno pubescentis*–*Schoenetum nigricantis* *pycnostachetosum reticulatae* subass. nova hoc loco

Nomenclatural type: relevé 23 (holotypus).

*Environmental data:* dense moist herbland (reedbed) and grassland along permanent mountain streams occurs on gentle midslopes and footslopes of  $1$ – $3^\circ$ . Rock cover is  $\pm 5$ – $15\%$  and small rocks, 50–150 mm in diameter (Table 3).

*Diagnostic and dominant/prominent taxa:* characteristic species are represented by species group AC and AG (Table 1b). No woody or grass species are diagnostic of this community. Characteristic forb species include the sedges *Cyperus sexangularis* and *Kyllinga erecta*, and the forb *Berula erecta*. Dominant grass species are *Miscanthus junceus* and *Phragmites australis*, the forbs *Pycnostachys reticulata* and *Senecio gerrardii*, and the sedges *Fuirena pubescens*, *Schoenoplectus corymbosus* and *Schoenus nigricans*. *Andropogon eucomis*, *Cymbopogon validus* and *Hyparrhenia filipendula* are prominent grasses.

*Floristic diversity:* a floristic affinity exists with the adjacent grassland plant community 3.4 (species group L) (Table 1a), and with the wetland plant community 7 (species group AG) (Table 1b). The average number of species encountered per sample plot is 27, with the total number for this subassociation being 42 (three relevés) (Table 3). Only two taxa of conservation value, namely Red Data List taxa, are found in this subassociation (Table 2).

#### 6.3. *Fuireno pubescentis*–*Schoenetum nigricantis* *bulbostylietosum hispidulae* subass. nova hoc loco

Nomenclatural type: relevé 34 (holotypus).

*Environmental data:* herbland and grassland occurs in moist valley bottoms or on mountain crests, usually in non-permanent seepage areas along streams. It is associated with gentle slopes of  $1$ – $3^\circ$ . Scattered stones cover  $\pm 10$ – $20\%$  of the soil surface with an average diameter of 50–100 mm (Table 3).

*Diagnostic and dominant/prominent taxa:* diagnostic species are presented in species group AD (Table 1b), including the forbs, *Alepidea amatymbica* and *Bulbostylis hispidula*, and the grasses, *Bothriochloa insculpta* and *Microchloa caffra*. The woody *Rhus leptodictya* is a prominent species. Predominant forbs include *Artemisia afra* and *Cliffortia nitidula*, and the sedges *Mariscus congestus* and *Schoenus nigricans*. *Andropogon eucomis*, *Cymbopogon validus*, *Hyparrhenia filipendula*, *Ischaemum fasciculatum* and *Miscanthus junceus* are the dominant grasses.

*Floristic diversity:* a strong floristic affinity exists with the grassland community 4.1 (species group O), but



a distinct affinity also exists with the wetland plant community 7 in species group AH (Table 1b). In this subassociation the sedges are less prominent and should be seen as a moist grassland-wetland ecotone. The average number of species encountered per sample plot is 25, with 52 taxa the total number for this subassociation (four relevés) (Table 3). There are four taxa of conservation value that include one SCPE endemic, one SCPE near-endemic and three Red Data List taxa (Table 2).

7. *Andropogono eucomusae-Fimbristyletum ferrugineae* ass. nova hoc loco

Nomenclatural type: relevé 192 (holotypus).

*Environmental data*: wooded herbland and grassland along larger rivers in valleys, such as the Steelpoort River. The vegetation covers the zone directly adjacent to streams, on permanently moist soils. The area has a gentle slope of 1–3°. Rock cover is  $\pm$  20–30% and rock diameter is 150–200 mm (Table 3).

*Diagnostic and dominant/prominent taxa*: diagnostic species are represented by species group AF (Table 1b). The vegetation unit is dominated by diagnostic forbs, which include the prominent weedy aliens *Conyza bonariensis* and *Flaveria bidentis*, the sedges *Cyperus marginatus*, *Mariscus rehmannianus*, *M. sumatrensis*, and the forb *Polygonum meisnerianum*. The presence of weeds is the result of disturbance caused by annual floods. *Salix mucronata* is the diagnostic woody species and *Eragrostis gummiflua* the diagnostic grass. Hygrophilous grasses and sedges such as *Miscanthus junceus* and *Schoenoplectus corymbosus* are dominant. *Acacia karroo* and *Rhus leptodictya* are common small trees of the association. *Andropogon eucomis*, *Cymbopogon validus*, *Hemarthria altissima*, *Hyparrhenia hirta* and *Imperata cylindrica* are dominant grasses of the association.

*Floristic diversity*: a strong floristic affinity exists with the wetland plant community 6 (species group AI) and a weaker affinity with the grasslands (species group Y) (Table 1b). The average number of species encountered per sample plot is 27, with the total number of plant species being 52 taxa (four relevés) (Table 3). This association has the lowest number of taxa with a conservation status (Table 2), including the Red Data List taxon *Eucomis autumnalis* subsp. *clavata*, which is classified as Rare in the Free State and Vulnerable in KwaZulu-Natal, and the SCPE endemic form of *Acacia karroo*.

### III. Drakensberg escarpment wetlands (Hilliard & Burt 1987)

8. *Limosello maioris-Ranunculetum meyeri* ass. nova hoc loco

Nomenclatural type: relevé 410 (holotypus).

*Environmental data*: this rare association represents dense herbland of moist seepage areas, recorded only on the summit plateaus of the Leolo Mountains around 1 800 m and is usually associated with black, marshy clay soils. A short, dense cover of nongrassy forbs dominates the vegetation. It lies on gentle slopes of 1–3° and  $\pm$  10% of the soil surface is covered by small stones with

an average diameter of 50 mm (Table 3).

*Diagnostic and dominant/prominent taxa*: diagnostic species are represented by species group AJ (Table 1b). The most predominant diagnostic taxa of the association are the small forbs *Limosella maior*, *Ranunculus meyeri* and *R. multifidus*. *Sporobolus centrifugus* is the diagnostic grass. *Schoenoplectus corymbosus* is a dominant sedge in the association.

*Floristic diversity*: a very slight floristic affinity exists with the other wetland plant communities of the area (species group AK) and also with the grasslands of the study area (species group Y) (Table 1b). It is much related to similar wetland communities below the Drakensberg escarpment above 1 800 m (Hilliard & Burt 1987). The average number of species encountered per sample plot is 20, with the total number of plant species being 24 taxa (two relevés) (Table 3). Together with plant community 7, this association has the lowest number of taxa with a conservation status, namely two. These include the Red Data List species *Eucomis autumnalis* subsp. *clavata*, and the undescribed SCPE endemic *Tulbaghia* sp. (Siebert 1304), which may be a new genus of the Alliaceae.

#### Vegetation key

A dichotomous vegetation key is presented to facilitate identification of the various syntaxa found in the study area (Table 4). The definitions are broad indications of the syntaxa and should be seen as a guideline, rather than precise descriptions. A diagnostic characteristic of the vegetation or habitat is given, followed by the most diagnostic and conspicuous species of a particular syntaxon. The first species listed is restricted to the specific syntaxon only, and the second is dominant in the syntaxon, but may occur in other syntaxa. Where one species is given, no species were restricted to the particular syntaxon only.

#### Ordination

A scatter diagram displaying the distribution of the relevés along the second and third ordination axes is presented for both grassland and wetlands in Figure 2 (eigen values: axis 2 = 0.471; axis 3 = 0.325) and Figure 3 (eigen values: axis 2 = 0.458; axis 3 = 0.256) respectively. Vegetation units are represented as clusters, their distribution on the scatter diagram corresponding with certain physical environmental conditions. The gradient described by the x-axis in both instances, is related to drainage and hence, soil moisture. In the grasslands, the communities with the highest available soil moisture are situated at the left of the diagram (Figure 2), but communities of the wetlands with poor drainage on waterlogged soils are to the right (Figure 3). In addition, communities of the grasslands on clay soils of steep slopes are situated to the left of the diagram and communities on gravel soils of steep slopes to the right (Figure 2). The clay soils have the highest moisture availability, although the run-off is high. Grassland communities of turf soils on moderate slopes are positioned in the centre of the diagram, because these soils have a high soil moisture percentage, which is unavailable due to reten-



TABLE 4.—Key to syntaxa of grasslands and wetlands of undulating norite hills of Sekhukhuneland Centre of Plant Endemism

Leads/description	Go to/syntaxon
1a Grassland ( <i>Tristachya leucothrix</i> & <i>Senecio microglossus</i> )	2
b Wetland ( <i>Schoenoplectus corymbosus</i> & <i>Cymbopogon validus</i> )	3
2a Mispah soils on footslopes ( <i>Jamesbrittenia macrantha</i> & <i>Dicola anomala</i> )	4
b Other soils and terrain types ( <i>Tristachya leucothrix</i> )	5
3a High-altitude seepage ( <i>Ranunculus meyeri</i> & <i>Schoenoplectus corymbosus</i> )	8 <i>Limosello maioris</i> – <i>Ranunculetum meyeri</i>
b Streams/rivers ( <i>Fuirena pubescens</i> & <i>Schoenoplectus corymbosus</i> )	6
4a Gentle sloped ( <i>Euclea linearis</i> & <i>Loudetia simplex</i> )	5.2 <i>Jamesbrittenia macranthae</i> – <i>Loudetietum simplicis eucleetosum linearis</i>
b Larger rock size and cover ( <i>Combretum hereroense</i> & <i>Brachiaria serrata</i> )	5.1 <i>Jamesbrittenia macranthae</i> – <i>Loudetietum simplicis combretetosum hereroense</i>
5a Higher altitudes ( <i>Helichrysus splendendum</i> & <i>Pentstemonis prunelloides</i> )	1 <i>Helichryso splendidi</i> – <i>Tristachyetum leucothricis</i>
b Lower altitudes ( <i>Acacia caffra</i> )	7
6a Valley rivers ( <i>Mariscus rehmianus</i> & <i>Andropogon eucomis</i> )	7 <i>Andropogono eucomusae</i> – <i>Fimbristyletum ferrugineae</i>
b Mountain streams ( <i>Schoenus nigricans</i> & <i>Miscanthus junceus</i> )	8
7a Larger rock size and cover ( <i>Zantedeschia pentlandii</i> & <i>Aloe castanea</i> )	2 <i>Zantedeschio pentlandii</i> – <i>Aloetum castanea</i>
b No Mispah soils ( <i>Trachypogon spicatus</i> )	9
8a Rocky streams ( <i>Cyperus sexangularis</i> & <i>Hyparrhenia tanba</i> )	10
b Stream seepage ( <i>Bulbostylis hispidula</i> & <i>Chironia purpurascens</i> )	6.3 <i>Fuireno pubescentis</i> – <i>Schoenetum nigricantis bulbostylietum hispidulae</i>
9a Vertic A-horizon ( <i>Rhynchosia prinoidea</i> & <i>Setaria sphacelata</i> )	11
b Melanic A-horizon ( <i>Rhynchosia spectabilis</i> & <i>Protea caffra</i> )	12
10a Level slope ( <i>Cyperus sexangularis</i> & <i>Berula erecta</i> )	6.2 <i>Fuireno pubescentis</i> – <i>Schoenetum nigricantis pycnostachetosum reticulatae</i>
b Steeper slope, more rocky ( <i>Triplaris andropogonoides</i> & <i>Kyllinga erecta</i> )	6.1 <i>Fuireno pubescentis</i> – <i>Schoenetum nigricantis triplarietosum andropogonoides</i>
11a Lower rock cover percentage ( <i>Acacia tortilis</i> & <i>Hyparrhenia filipendula</i> )	4.2 <i>Elionuro mutici</i> – <i>Trachypogonetum spicati acaciotosum tortilis</i>
b Steeper slope ( <i>Pearsonia grandifolia</i> & <i>Senecio microglossus</i> )	13
12a All aspects ( <i>Helichrysus rugulosus</i> & <i>Clerodendrum triphyllum</i> )	14
b East-west aspects ( <i>Vernonia oligocephala</i> )	15
13a Steadland soils ( <i>Bewisia biflora</i> & <i>Tephrosia purpurea</i> )	4.1 <i>Elionuro mutici</i> – <i>Trachypogonetum spicati bewisietosum biflorae</i>
b Arcadia soils ( <i>Setaria nigrirostris</i> & <i>Callitriche leptophylla</i> )	3.4 <i>Brachiario serratae</i> – <i>Melhanietum randii setarietosum nigrirostris</i>
14a Milkwood soils, midslopes ( <i>Alloterospis semialata</i> & <i>Hyparrhenia hirta</i> )	3.1.2 <i>Brachiario serratae</i> – <i>Melhanietum randii helichrysosum rugulosi</i> , <i>Alloterospis semialata</i> variant
b Mayo soils, scarps and crests ( <i>Digitaria eriantha</i> & <i>Tetraselago wilmsii</i> )	3.1.1 <i>Brachiario serratae</i> – <i>Melhanietum randii helichrysosum rugulosi</i> , <i>Digitaria eriantha</i> variant
15a Footslopes/midslopes ( <i>Vernonia galpinii</i> )	3.3 <i>Brachiario serratae</i> – <i>Melhanietum randii gnidiotosum capitatae</i>
b Midslopes/crests ( <i>Berkheya seminivea</i> )	16
16a Higher rock cover ( <i>Argyrolobium transvaalense</i> )	3.2.2 <i>Brachiario serratae</i> – <i>Melhanietum randii argyrolobietosum transvaalense</i> , <i>Berkheya seminivea</i> variant
b Larger rock size ( <i>Koeleria capensis</i> )	3.2.1 <i>Brachiario serratae</i> – <i>Melhanietum randii argyrolobietosum transvaalense</i> , <i>Koeleria capensis</i> variant

tion by the soil particles. The gradient shown by the y-axis for communities of wetlands is that of topographic position (Figure 3). Here, the water systems of mountain slopes with a faster run-off are placed at the top of the scatter diagram. Perennial seepage systems of plateaus are centred in the middle of the diagram, and communities of permanent, slow-flowing rivers are located at the bottom.

The gradient along the first axis of Figure 2 is also an indication of the species diversity in the grasslands, with the species diversity at the left of the diagram being high-

er than that of the communities at the right. This phenomenon can be attributed to the heterogeneous environment experienced by most *Brachiario serratae*–*Melhanietum randii* rocky grassland communities.

The gradients that have been identified are associated with each other and have a strong influence on the vegetation. The three most dominant and conspicuous taxa of each growth form (trees/shrubs/suffrutesces, forbs/sedges and grasses) are given for each of the eight major vegetation types depicted in the scatter diagram (Table 5).

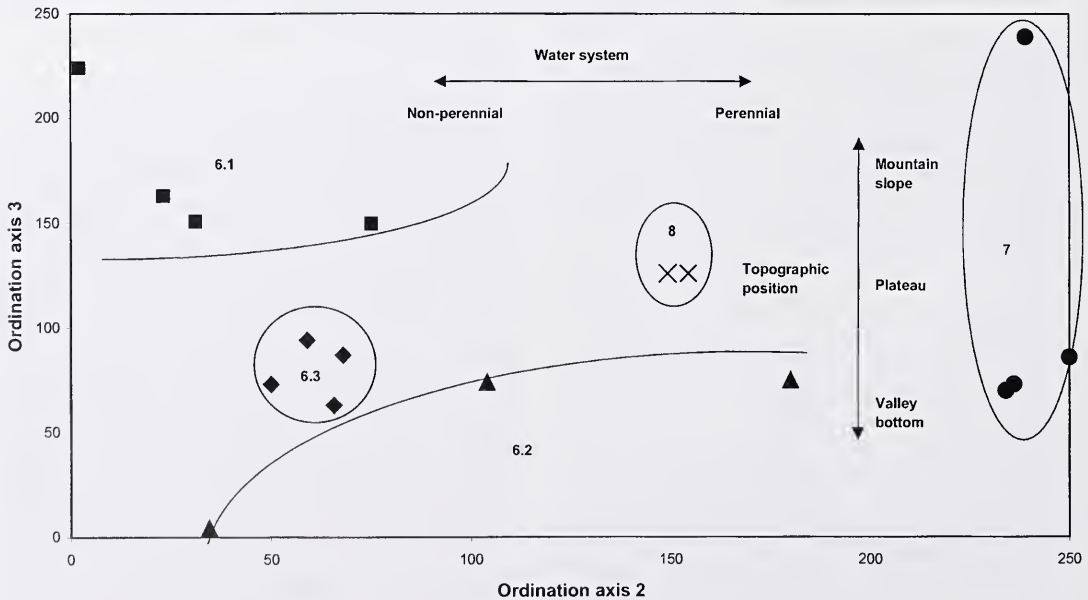


FIGURE 3.—Relative positions of all the relevés along the second and third axis of the ordination of the wetland vegetation of the Sekhukhuneland Centre of Plant Endemism. Numbers correspond with those of syntaxa in Table 1b and in the text.

TABLE 5.—Three most dominant and conspicuous plant taxa of each growth form recorded for the major vegetation types depicted in DECORANA scatter diagrams (Figures 2, 3)

Major vegetation type	Growth form		
	Trees/shrubs/suffrutescis	Forbs/sedges	Grasses
1 <i>Helichryso splendidi</i> – <i>Tristachyetum leucothricis</i>	<i>Buddleja saligna</i> <i>Clutia pulchella</i> <i>Protea caffra</i> [form]	<i>Euryops brevipapposus</i> <i>Helichrysum splendidum</i> <i>Pentanisia prunelloides</i>	<i>Eragrostis capensis</i> <i>Eragrostis curvula</i> <i>Tristachya leucothrix</i>
2 <i>Zantedeschio pentlandi</i> – <i>Aloetum castaneae</i>	<i>Apodytes dimidiata</i> <i>Canthium suberosum</i> <i>Halleria lucida</i>	<i>Aloe castanea</i> <i>Crassula sarcocaulis</i> <i>Zantedeschia pentlandii</i>	<i>Aristida junciformis</i> <i>Cymbopogon excavatus</i> <i>Eragrostis pseudosclerantha</i>
3 <i>Brachiario serratae</i> – <i>Melhanietum randii</i>	<i>Elephantorrhiza elephantina</i> <i>Protea caffra</i> [form] <i>Rhus wilmsii</i>	<i>Clerodendrum triphyllum</i> <i>Melhania randii</i> <i>Vernonia oligocephala</i>	<i>Andropogon chinensis</i> <i>Brachiaria serrata</i> <i>Tristachya leucothrix</i>
4 <i>Elionuro mutici</i> – <i>Trachypogonetum spicati</i>	<i>Rhamnus prinoides</i> <i>Rhus rogersii</i> <i>Vitex obovata</i>	<i>Berkheya insignis</i> <i>Cephalaria zeyheriana</i> <i>Gnidia caffra</i>	<i>Elionurus muticus</i> <i>Setaria spachelata</i> <i>Trachypogon spicatus</i>
5 <i>Jamesbrittenio macranthae</i> – <i>Loudetietum simplicis</i>	<i>Elephantorrhiza praetermissa</i> <i>Protea caffra</i> [form] <i>Vitex obovata</i>	<i>Helichrysum uninervium</i> <i>Jamesbrittenia macrantha</i> <i>Thesium multiramulosum</i>	<i>Aristida adscensionis</i> <i>Loudetia simplex</i> <i>Melinis repens</i>
6 <i>Fuireno pubescentis</i> – <i>Schoenetum nigricantis</i>	<i>Acacia karroo</i> <i>Nuxia gracilis</i> <i>Rhus leptodictya</i>	<i>Fuirena pubescens</i> <i>Schoenus nigricans</i> <i>Typha capensis</i>	<i>Hyparrhenia filipendula</i> <i>Hyparrhenia tamba</i> <i>Imperata cylindrica</i>
7 <i>Andropogono eucomusae</i> – <i>Fimbristyletum ferrugineae</i>	<i>Acacia karroo</i> <i>Rhus leptodictya</i> <i>Salix mucronata</i>	<i>Cyperus sphaerospermus</i> <i>Fimbristylis ferruginea</i> <i>Mariscus rehmannianus</i>	<i>Andropogon eucomis</i> <i>Eragrostis gunniflua</i> <i>Phragmites australis</i>
8 <i>Limosello maioris</i> – <i>Ranunculetum meyeri</i>	No trees/shrubs	<i>Limosella maior</i> <i>Ranunculus meyeri</i> <i>Ranunculus multifidus</i>	<i>Eragrostis capensis</i> <i>Heteropogon contortus</i> <i>Sporobolus centrifugus</i>

DISCUSSION

Plant diversity and geographic variations over southern Africa are best explained by the geology (soils) and climate, with topographic diversity explaining much of the remaining variance (Holland 1978; Schulze & McGee 1978). Much of the distribution of the syntaxa in the study area can be attributed to fire, and the vegetation dynamics and historic evolution of the flora of the region (Siebert 1998), which is influenced by the above-mentioned three factors.

The TWINSPLAN classification and its subsequent refinement by Braun-Blanquet procedures resulted in the delineation of 17 syntaxa. These plant communities can be related to certain environmental factors, the gradients of which are illustrated in the DECORANA scatter diagrams. The major gradient relates to soil moisture, which in turn is a direct consequence of run-off and drainage in the case of grasslands, permanent water bodies/sources in the case of wetlands, and temperature (drought stress) in both cases. Soil moisture availability is determined by the soil type, which in turn was determined by the topographical position of the substrate during pedogenesis. The gradients of the diagram are therefore a direct consequence of topography and climate.

In the SCPE, soils of ultramafic origin have caused the development of syntaxa adapted to the specific soil conditions, with high concentrations of certain elements, notably heavy metals. Such a plant community (syntaxon)-soil association on ultramafic substrates has previously been identified for southern Africa, on the Great Dyke of Zimbabwe (Werger *et al.* 1978) and the Barberton Greenstone Belt in South Africa (Morrey *et al.* 1989). Because of the ultramafic nature of the norites of the Roossenekal and Leolo Subcentres, many taxa of the

study area are uncommon or absent in other grassland areas of southern Africa.

Among the 17 plant communities, 44 plant species/infraspecific taxa were identified as of conservation significance. Fifteen were SCPE endemics and 19 SCPE near-endemics. Of the 44, 17 were listed in the southern African Red Data List for plants (Hilton-Taylor 1996). This number compares well with serpentine sites elsewhere in the world, namely 18 rare plants and endemics in central Queensland, Australia (Batianoff *et al.* 1995), 20 endemics on the Great Dyke, Zimbabwe (Wild 1965) and 22 endemics in southern Mpumalanga, South Africa (Balkwill *et al.* 1995).

Species richness of Sekhukhuneland grassland communities is high when compared with the grassland species richness of other parts of South Africa. Sekhukhuneland grasslands have a species richness of 20 to 51 species per 100 m<sup>2</sup> with a mean of 38 species (Table 3). This mean is higher than that recorded for the grasslands of the northeastern Drakensberg (Mpumalanga) and southern Drakensberg (Eastern Cape), but is lower than that of the Highveld (Gauteng/Mpumalanga) (Hoare & Bredenkamp 2001). Floristically the Grasslands of the study area are related to those described by Bloem (1988), Deall *et al.* (1989), Matthews *et al.* (1992a), Burgoyne (1995) and Smit *et al.* (1997).

Throughout the SCPE, the remaining natural populations of plants and animals are under intense pressure from exploitative land uses. There are certain areas with specific syntaxa that should be considered as a priority for conservation purposes. Some plant endemics of the southern region of the SCPE are restricted to specific syntaxa and these habitats therefore require urgent attention for conservation as a result of the rapid expanding



mining industry, a common threat to southern Africa's rich plant diversity (Dold & Johnson 1997). Biodiversity increases ecosystem stability by promoting diversity among species in their responses to environmental fluctuations (Naeem & Li 1997; Grime 1998; Ives *et al.* 1999) and hence, is imperative for successful conservation initiatives. The establishment of nature reserves or protected areas is one solution to this problem of biodiversity loss; this is best achieved through land use stratification derived from a holistic overview. Such a strategic environmental assessment, which includes an adequate database of natural features and other land uses (Bedward *et al.* 1992), should be a priority for conservation agencies in the region.

The priority vegetation types for conservation (hotspots) are associations 2, 3 and 4, of which subassociation 3.1, the *Brachiario serratae-Melhanietum randii helichrysetosum rugulosi* rocky grassland on the scarps and crests of norite hills, is probably the most important and threatened. It should also be noted that the wetlands are sensitive systems that are easily disturbed and should be protected (Doust & Doust 1995; Van Wyk *et al.* 2000). Important wetlands to conserve are the seepage areas, namely the *Limosello maioris-Ranunculetum meyeri* Association and the *Fuireno pubescentis-Schoenetum nigricantis bulbostylietosum hispidulae* Subassociation.

Alien species primarily invade areas of high indigenous species richness (Lonsdale 1999; Stohlgren *et al.* 1999), such as the grasslands of southern Africa. *Acacia dealbata*, an alien tree from Australia, has invaded large areas of the Roossenekal Subcentre and especially the adjacent Steenkampsberg. Removing these trees is totally dependent on the owner of the land, with no large-scale projects being implemented. It is an ironic situation, with people 50 km to the north extensively chopping down indigenous bushveld trees for firewood.

This description and classification of the syntaxa of the study area is a contribution towards the understanding of the vegetation and flora in the southern parts of the SCPE and the region as a whole. The information supplied here should be applied in the management and conservation of the vegetation and habitats, especially the rocky grasslands that are threatened by the mining industry and inappropriate forms of land use, specifically overgrazing by domestic stock. This paper provides a basis for proper and sound assessment of the region's vegetation, as it includes aspects such as species richness, rarity and habitat preference. Detailed site-specific studies, using this paper as a reference, remain a prerequisite before suggestions concerning mining or conservation can be made. The region boasts a rich natural and human history (Pollock *et al.* 1963), and representative ecologically viable portions of the grasslands of the region, as well as the wetlands, should be protected and conserved for future generations.

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## Miscellaneous notes

### POACEAE

#### CHROMOSOME STUDIES ON AFRICAN PLANTS. 17. THE SUBFAMILIES ARUNDINOIDEAE AND DANTHONIOIDEAE

Cytogenetic studies in our laboratory focused on the former grass subfamily Arundinoideae and we have published chromosome numbers of 422 specimens, representing 12 genera and 54 species (Du Plessis & Spies 1988; Spies & Du Plessis 1988; Spies *et al.* 1990, 1992; Du Plessis & Spies 1992; Spies *et al.* 1994; Visser & Spies 1994b, d, e; Klopper *et al.* 1998; Spies & Roodt 2001). This subfamily was recently subdivided into two separate subfamilies, the Arundinoideae and Danthonioideae by the Grass Phylogeny Working Group (GPWG 2001): the Arundinoideae, represented by *Styppeiochloa* De Winter, has basic chromosome numbers of 6, 9 and 12 and the Danthonioideae, represented by *Chaetobromus* Nees, *Karroochloa* Conert & Türpe, *Merxmüllera* Conert, *Pentameris* P.Beauv., *Pentaschistis* Stapf, *Pseudopentameris* Conert, *Schismus* P.Beauv. and *Tribolium* Desv., has  $x = 6, 7$  and  $9$ .

This is a chromosome number report for the two subfamilies.

#### MATERIALS AND METHODS

Cytogenetic material of identical plants of a population was collected and fixed in the field. Voucher specimens, listed in Table 1, are housed in the Geo Potts

Herbarium, Department of Botany and Genetics, University of the Free State, Bloemfontein (BLFU) or in the National Herbarium, Pretoria (PRE).

Anthers were squashed in aceto-carmine and meiotically analysed—at least 20 cells per meiotic stage were studied (Spies *et al.* 1996). Only gametic chromosome numbers are presented to conform to previous papers on chromosome numbers in this journal (Spies & Du Plessis 1986).

#### RESULTS AND DISCUSSION

One hundred and nineteen plants, representing 38 species and 9 genera, were studied (Table 1).

#### Arundinoideae

Three specimens of the monospecific genus *Styppeiochloa*, *S. gynoglossa*, were studied. Two specimens had  $n = 2x = 12$ , and one octaploid specimen ( $n = 4x = 24$ ) was found (Figure 1A). These specimens represent the first known chromosome number reports for this genus and six is the original basic chromosome number. Twelve is probably a secondarily derived basic chromosome number.

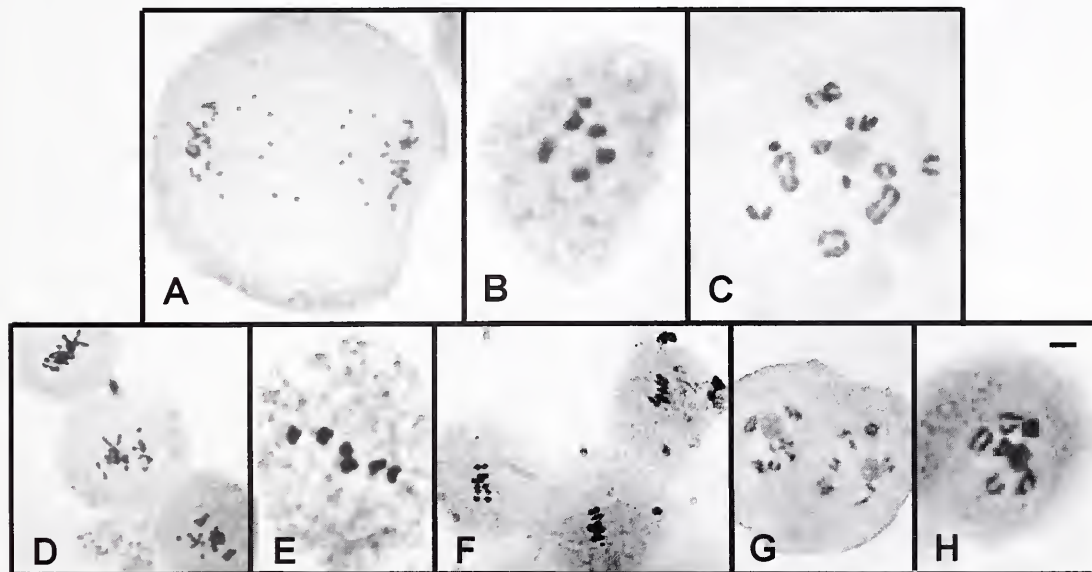


FIGURE 1.—Meiotic chromosomes in *Styppeiochloa* and *Karroochloa*. A, *Styppeiochloa gynoglossa*, Saayman 79,  $2n = 8x = 48$ , with chromosomal laggards; B, *Karroochloa curva*, Spies 4518,  $2n = 2x = 12$ , diakinesis with  $6_{II}$ . C–E, *K. purpurea*: C, D, Spies 2473,  $2n = 4x = 24+2-5B$ ; C, diakinesis with  $3_{IV}$ ,  $6_{II}$  and 5B (two B chromosomes paired); D, metaphase I with B chromosomes not on metaphase plate; E, Spies 2477,  $2n = 2x = 12$ , metaphase I. F, G, *K. schismoides*: F, Spies 3371,  $2n = 2x = 12$ , metaphase I; G, Spies 3382,  $2n = 2x = 12$ , cell fusion resulting in 12 bivalents and two micronuclei during diakinesis. H, *Karroochloa* species, Spies 5192,  $2n = 2x = 12$ , diakinesis with  $6_{II}$ . Scale bar: B, 5  $\mu$ m; B, C, E, H, 8  $\mu$ m; D, F, G, 15  $\mu$ m.



TABLE 1.—Gametic chromosome numbers (n) of representatives of subfamilies Arundinoideae and Danthonioideae (Poaceae) in southern Africa with their voucher specimen numbers and specific localities. Species are listed alphabetically and localities presented according to Edwards & Leistner (1971)

Taxon	n	Voucher	Locality
<b>Arundinoideae</b>			
<i>Styppeiochloa gynoglossa</i> (Gooss.) De Winter	12	<i>Spies 1485</i>	MPUMALANGA.—2530 (Lydenburg): in the Steenkampsberge, 6 km from Goede Hoop to Roosenekal, (–AA).
	12	<i>Spies 2642</i>	SWAZILAND.—2631 (Mbabane): Moimba beacon, 16 km from Mbabane to Oshoek, (–AD).
	24	<i>Saayman 79</i>	MPUMALANGA.—2430 (Pilgrim’s Rest): 3 km from Graskop to Bosbokrand, (–DD).
<b>Danthonioideae</b>			
<i>Chaetobromus involucratus</i> (Schräd.) Nees subsp. <i>dregeanus</i> (Nees) Verboom	6	<i>Spies 5691</i>	NORTHERN CAPE.—2917 (Springbok): 78 km from Steinkopf to Port Nolloth, (–BA).
<i>Karoochloa curva</i> (Nees) Conert & Türpe	6	<i>Spies 4518</i>	WESTERN CAPE.—3420 (Bredasdorp): 25 km from Swellendam to Ashton, (–AB).
<i>K. purpurea</i> (L.f.) Conert & Türpe	6	<i>Spies 3370</i>	NORTHERN CAPE.—2918 (Gamoep): 26 km southeast from Springbok to Garies, (–CA).
	6	<i>Spies 4542</i>	WESTERN CAPE.—3319 (Worcester): 69 km from Montagu to Touwsriver, (–DB).
	6	<i>Spies 4536</i>	WESTERN CAPE.—3320 (Montagu): 61 km from Montagu to Touwsriver, (–CD).
<i>K. schismoides</i> (Stapf ex Conert) Conert & Türpe	6+0-2B	<i>Spies 2473, 2477</i>	EASTERN CAPE.—3126 (Queenstown): Penhoek Pass, (–BC).
	6	<i>Spies 2826</i>	NORTHERN CAPE.—2917 (Springbok): 34 km from Port Nolloth to Steinkopf, (–CA).
	6	<i>Spies 2976</i>	NORTHERN CAPE.—2917 (Springbok): 25 km east of Port Nolloth, (–AC).
	6	<i>Spies 3357</i>	NORTHERN CAPE.—2917 (Springbok): 36 km from Port Nolloth to Kleinsee, (–AC).
	6	<i>Spies 4276</i>	NORTHERN CAPE.—2917 (Springbok): 13 km from Springbok on road to Hondeklipbaai, (–DB).
	6	<i>Spies 3371</i>	NORTHERN CAPE.—2918 (Gamoep): 26 km southeast from Springbok to Garies, (–CA).
	6	<i>Spies 3382</i>	NORTHERN CAPE.—3017 (Hondeklipbaai): 42 km west of Garies to Groentrivier, (–DC).
	6	<i>Spies 3081</i>	WESTERN CAPE.—3118 (Vanrhynsdorp): 15 km north of Vanrhynsdorp, (–AD).
	6	<i>Spies 4350</i>	NORTHERN CAPE.—3119 (Calvinia): 35 km from Vanrhynsdorp to Nieuwoudtville, (–AC).
	6	<i>Spies 5192</i>	EASTERN CAPE.—3324 (Steytlerville): 25 km from Patensie to Willowmore, (–DA).
<i>Merxmüllera cincta</i> (Nees) Conert	18	<i>Spies 3504</i>	EASTERN CAPE.—3424 (Humansdorp): 16 km from Humansdorp to Cape St Frances, (–BB).
<i>M. decora</i> (Nees) Conert	24	<i>Spies 4407</i>	WESTERN CAPE.—3219 (Wuppertal): 3 km from Algeria to Citrusdal, (–AC).
	24	<i>Spies 4458</i>	WESTERN CAPE.—3419 (Caledon): 21 km from Franschoek to Villiersdorp, (–AA).
	24	<i>Spies 3465</i>	WESTERN CAPE.—3420 (Bredasdorp): 8 km south from Ouplaas to De Hoop Nature Reserve, (–AD).
<i>M. disticha</i> (Nees) Conert	24	<i>Spies 4751</i>	EASTERN CAPE.—3027 (Lady Grey): 43 km from Barkley East to Lady Grey, (–CA).
<i>M. drakensbergensis</i> (Schweick.) Conert	18	<i>Spies 4676</i>	EASTERN CAPE.—3028 (Matatiele): 12 km from Rhodes to Naude’s Nek, (–CC).
	18	<i>Spies 4687</i>	EASTERN CAPE.—3028 (Matatiele): 22 km from Rhodes on road to Barkley East, (–CC).
<i>M. lupulina</i> (Thunb.) Conert	24	<i>Spies 4601</i>	WESTERN CAPE.—3319 (Worcester): Du Toitskloof next to tunnel, (–AC).
<i>M. macowanii</i> (Stapf) Conert	24	<i>Spies 4724</i>	EASTERN CAPE.—3027 (Lady Grey): 37 km from Rhodes via Luncheon’s Nek, (–DD).
	24	<i>Spies 4727</i>	EASTERN CAPE.—3027 (Lady Grey): 50 km from Rhodes via Luncheon’s Nek, (–DD).
	24	<i>Spies 4757</i>	EASTERN CAPE.—3027 (Lady Grey): 65 km from Barkley East to Lady Grey via Joubert’s Pass, (–CA).
	24	<i>Spies 4682</i>	EASTERN CAPE.—3028 (Matatiele): 16 km from Rhodes via Naude’s Nek, (–CC).
	24	<i>Spies 4402</i>	WESTERN CAPE.—3219 (Wuppertal): top of Uitkyk Pass, (–AC).
	12	<i>Spies 6288</i>	NORTHERN CAPE.—3119 (Calvinia): 41 km from Vanrhynsdorp on Vanrhyns Pass, (–AC).
	12	<i>Spies 4384</i>	WESTERN CAPE.—3218 (Clanwilliam): Uitkyk Pass, (–AC).
	12	<i>Spies 3695</i>	WESTERN CAPE.—3219 (Wuppertal): 22 km from Clanwilliam to Calvinia, (–AA).
	12	<i>Davidse 33333, 33939, 34091</i>	Localities unknown.
	18	<i>Spies 4339</i>	NORTHERN CAPE.—3118 (Vanrhynsdorp): Gifberg Pass, (–DC).
<i>M. rufa</i> (Nees) Conert	18	<i>Spies 4351</i>	NORTHERN CAPE.—3119 (Calvinia): 41 km from Vanrhynsdorp on Vanrhyns Pass, (–AC).

TABLE 1.—Gametic chromosome numbers (n) of representatives of subfamilies Arundinoideae and Danthonioideae (Poaceae) in southern Africa with their voucher specimen numbers and specific localities. Species are listed alphabetically and localities presented according to Edwards & Leistner (1971) (cont.)

Taxon	n	Voucher	Locality
<i>M. stricta</i> (Schrad.) Conert	18	<i>Spies 3839</i>	WESTERN CAPE.—3218 (Clanwilliam): Uitkyk Pass, (–AC).
	18	<i>Spies 3147</i>	WESTERN CAPE.—3219 (Wuppertal): 2 km from Houdenberg to Katbakkies Pass, (–DC).
	18	<i>Spies 3637</i>	WESTERN CAPE.—3319 (Worcester): 4 km from Franschoek turn-off on Villiersdorp-Grabouw road, (–CC).
	18	<i>Spies 3469</i>	WESTERN CAPE.—3419 (Caledon): Swartberg Pass, (–AA).
	18	<i>Spies 3618</i>	WESTERN CAPE.—3419 (Caledon): 18 km from Botriver to Villiersdorp via Vanderstel Pass, (–AA).
	18	<i>Davidse 33347, 34028, 34110, 34121</i>	Localities unknown.
	± 26	<i>Spies 3140</i>	WESTERN CAPE.—3220 (Sutherland): 15 km from Sutherland to Matjiesfontein, (–BC).
<i>Pentameris thuarii</i> P.Beauv.	7	<i>Spies 3541</i>	WESTERN CAPE.—3322 (Oudtshoorn): Montagu Pass, (–CD).
<i>Pentaschistis acinosa</i> Stapf	7	<i>Spies 5981</i>	WESTERN CAPE.—3218 (Clanwilliam): 40 km from Clanwilliam to Lamberts Bay, (–AB).
	7	<i>Spies 6033, 6035</i>	WESTERN CAPE.—3218 (Clanwilliam): 32 km from Clanwilliam to Nieuwoudtville at Klawer turn-off, (–BB).
	7	<i>Spies 3650</i>	WESTERN CAPE.—3318 (Cape Town): Table Mountain, (–CD).
<i>P. airoides</i> (Nees) Stapf subsp. <i>airoides</i>	7	<i>Spies 5946</i>	NORTHERN CAPE.—3018 (Kamieskroon): 5 km from Kamieskroon to Leliehoek, (–AC).
<i>P. airoides</i> (Nees) Stapf subsp. <i>jugorum</i> (Stapf) H.P.Linder	14	<i>Linder 4862</i>	FREE STATE.—2828 (Bethlehem): Bethlehem, Golden Gate National Park, (–DA)
<i>P. aristifolia</i> Schweick.	7	<i>Spies 6036</i>	WESTERN CAPE.—3218 (Clanwilliam): 32 km from Clanwilliam to Nieuwoudtville, at Klawer turn-off, (–BB).
	28	<i>Spies 6002</i>	WESTERN CAPE.—3218 (Clanwilliam): 14 km from Clanwilliam to Nieuwoudtville, (–BB).
<i>P. curvifolia</i> (Schrad.) Stapf	7	<i>Spies 5727</i>	WESTERN CAPE.—3118 (Vanhynsdorp): On top of Gifberg Pass, (–DC).
	7+1B	<i>Spies 6315</i>	WESTERN CAPE.—3218 (Clanwilliam): Uitkyk Pass, (–AC).
	7+1-2B	<i>Spies 4456</i>	WESTERN CAPE.—3319 (Worcester): 21 km from Franschoek to Villiersdorp, (–CC).
	7+0-2B	<i>Spies 6169</i>	WESTERN CAPE.—3322 (Oudtshoorn): Swartberg Pass, (–AC).
	7+0-4B	<i>Spies 6236</i>	WESTERN CAPE.—3419 (Caledon): Galgeberg, (–BA).
<i>P. densifolia</i> (Nees) Stapf	28	<i>Spies 6328</i>	WESTERN CAPE.—3219 (Wuppertal): on top of Nieuwoudt's Pass, (–AC).
<i>P. galpinii</i> (Stapf) McClean	7	<i>Linder +844</i>	EASTERN CAPE.—3028 (Matatiele): Barkley East, Naude's Nek, (–CC).
<i>P. pallida</i> (Thunb.) H.P.Linder	7	<i>Spies 5446</i>	WESTERN CAPE.—3418 (Simonstown): 7 km from Betty's Bay to Onrus, (–BD).
	7+1B	<i>Spies 5367</i>	WESTERN CAPE.—3218 (Clanwilliam): 13 km from bridge over Olifants River, (–DB).
	14	<i>Spies 5917</i>	NORTHERN CAPE.—2917 (Springbok): 24 km from Springbok to Hondeklipbaai, (–DB).
	14	<i>Spies 5737</i>	WESTERN CAPE.—3119 (Calvinia): on Vanrhyns Pass, (–AC).
	14	<i>Spies 6208</i>	WESTERN CAPE.—3420 (Bredasdorp): 1 km north of De Hoop Nature Reserve, (–AD).
<i>P. pappilosa</i> (Steud.) H.P.Linder	7+1B	<i>Spies 5445</i>	WESTERN CAPE.—3418 (Simonstown): 7 km from Betty's Bay to Onrus, (–BD).
<i>P. rigidissima</i> Pilg. ex H.P.Linder	7	<i>Spies 6243</i>	WESTERN CAPE.—3319 (Worcester): FM tower on Matroosberg, (–BC).
<i>P. rupestris</i> (Nees) Stapf	7	<i>Spies 6080</i>	WESTERN CAPE.—3219 (Wuppertal): 5 km from Algeria to Citrusdal, Nieuwoudt's Pass, (–AC).
	21	<i>Spies 4408</i>	WESTERN CAPE.—3219 (Wuppertal): 5 km from Algeria to Citrusdal, Nieuwoudt's Pass, (–AC).
	49/2	<i>Spies 4392</i>	WESTERN CAPE.—3219 (Wuppertal): Uitkyk Pass, (–AC).
	35	<i>Spies 6308</i>	WESTERN CAPE.—3219 (Wuppertal): Uitkyk Pass, (–AC).
	35	<i>Spies 6330</i>	WESTERN CAPE.—3219 (Wuppertal): on top of Nieuwoudt's Pass, (–AC).
	49	<i>Spies 6309, 6310</i>	WESTERN CAPE.—3219 (Wuppertal): Uitkyk Pass, (–AC).
<i>P. tomentella</i> Stapf	7	<i>Spies 4300, 6343</i>	NORTHERN CAPE.—3017 (Hondeklipbaai): 7 km from Kamieskroon to Leliefontein, (–BB).
	7+0-2B	<i>Spies 6344</i>	NORTHERN CAPE.—3017 (Hondeklipbaai): 7 km from Kamieskroon to Leliefontein, (–BB).
	14	<i>Spies 5301</i>	NORTHERN CAPE.—3119 (Calvinia): 7 km from Nieuwoudtville to Clanwilliam, (–AC).
	14	<i>Spies 5738</i>	NORTHERN CAPE.—3119 (Calvinia): on top of Vanrhyns Pass, (–AC).
<i>P. tortuosa</i> (Trin.) Stapf	7	<i>Spies 5425</i>	WESTERN CAPE.—3320 (Montagu): 24 km from Montagu to Touws River, Burger's Pass, (–AC).
	28	<i>Spies 6214</i>	WESTERN CAPE.—3420 (Bredasdorp): 5 km from Ouplaas to Malgas, (–AD).
<i>P. veneta</i> H.P.Linder	14	<i>Spies 6327</i>	WESTERN CAPE.—3219 (Wuppertal): on top of Nieuwoudt's Pass, (–AC).
<i>P. viscidula</i> (Nees) Stapf	14+0-2B	<i>Spies 6178</i>	WESTERN CAPE.—3322 (Oudtshoorn): Robinson's Pass, (–CC).
	35	<i>Spies 6020</i>	WESTERN CAPE.—3218 (Clanwilliam): 21 km from Clanwilliam to Nieuwoudtville, (–BB).
<i>Pseudopentameris macrantha</i> (Schrad.) Conert	7	<i>Spies 3431</i>	WESTERN CAPE.—3318 (Cape Town): Table Mountain, (–AB).

TABLE 1.—Gametic chromosome numbers (n) of representatives of subfamilies Arundinoideae and Danthonoideae (Poaceae) in southern Africa with their voucher specimen numbers and specific localities. Species are listed alphabetically and localities presented according to Edwards & Leistner (1971) (cont.)

Taxon	n	Voucher	Locality
<i>Schismus barbatus</i> (Loefl. ex L.) Thell.	6	<i>Spies 5284</i>	GAUTENG.—2528 (Pretoria): Pretoria, (–CA).
	6	<i>Spies 4273</i>	NORTHERN CAPE.—2917 (Springbok): 2 km from Springbok to Pofadder, (–DB).
	6	<i>Spies 4277, 4278, 4285</i>	NORTHERN CAPE.—2917 (Springbok): 13 km from Springbok to Hondeklipbaai, (–DB).
	6	<i>Spies 6596</i>	FREE STATE.—2925 (Jagersfontein): Petrusburg, (–AB).
	6	<i>Spies 4289</i>	NORTHERN CAPE.—3017 (Hondeklipbaai): 24 km from Soebatsfontein to Kamieskroon, (–BA).
	6	<i>Spies 4315</i>	NORTHERN CAPE.—3018 (Kamiesberg): 28 km from Leliefontein to Garies, (–AB).
	6	<i>Spies 4366</i>	WESTERN CAPE—3119 (Calvinia): 55 km from Nieuwoudtville to Clanwilliam, (–CC).
	6	<i>Davidse 34033, 34039</i>	WESTERN CAPE.—3219 (Wuppertal): 44 km from Clanwilliam to Calvinia, (–AA).
	6	<i>Spies 5342</i>	WESTERN CAPE.—3318 (Vanhynsdorp): Vanhynsdorp, (–DA).
	6	<i>Spies 4523</i>	WESTERN CAPE.—3320 (Montagu): 24 km from Montagu to Touws River, (–CC).
	6	<i>Spies 4524</i>	WESTERN CAPE—3320 (Montagu): 38 km from Montagu to Touws River, (–CC).
	6	<i>Spies 4308</i>	NORTHERN CAPE.—3017 (Hondeklipbaai): 18 km from Kamieskroon to Leliefontein, (–BA).
<i>S. inermis</i> (Stapf) C.E. Hubb	6	<i>Spies 4311</i>	NORTHERN CAPE.—3018 (Kamiesberg): 3 km from Leliefontein to Garies in Groenkloof, (–AB).
	6	<i>Spies 4575</i>	WESTERN CAPE.—3318 (Cape Town): Langebaan, (–DC).
	6	<i>Davidse 33758</i>	WESTERN CAPE.—3421 (Riversdale): 2 km south of Vermaaklikheid on road to Puntjie, (–AC).
	12	<i>Spies 4471</i>	WESTERN CAPE.—3420 (Bredasdorp): 1 km from Waenhuiskrans to Bredasdorp, (–CA).
	12	<i>Davidse 33804</i>	Locality unknown.
<i>S. scaberrimus</i> Nees	6	<i>Spies 4661</i>	NORTHERN CAPE.—3121 (Fraserburg): 55 km from Loxton to Fraserburg, (–DB).
	6	<i>Spies 4660</i>	NORTHERN CAPE.—3220 (Sutherland): 2 km from Sutherland to Calvinia, (–BC).
<i>Tribolium acutiflorum</i> (Nees) Renvoize	12	<i>Spies 3866</i>	WESTERN CAPE.—3319 (Worcester): 5 km from Gouda to Porterville, (–AC).
<i>T. hispidum</i> (Thunb.) Desv.	6	<i>Spies 4496</i>	WESTERN CAPE.—3420 (Bredasdorp): 1 km north of De Hoop Nature Reserve, (–CA).
	12	<i>Spies 3509</i>	EASTERN CAPE.—3424 (Humansdorp): 30 km from Humansdorp to Knysna, (–AA).
<i>T. obtusifolium</i> (Nees) Renvoize	18	<i>Davidse 34049</i>	Locality unknown.
<i>T. pusillum</i> (Nees) H.P.Linder & Davidse	6	<i>Davidse 34022</i>	WESTERN CAPE.—3218 (Clanwilliam): 7 km from Clanwilliam in Pakhuis Pass, (–BB).
<i>T. uniolae</i> (L.f.) Renvoize	12+0-2B	<i>Davidse 34166</i>	Locality unknown.

The two tetraploid specimens, *Spies 1485*, *2642*, with x-values of 0.829 and 1 respectively, agree with the 2:2 model of Kimber & Alonso (1981) (Table 2). The high x-value of *Spies 1485* indicates segmental allopolyploidy, with a tendency towards allopolyploidy. The other specimen, *Spies 2642*, has a value of 1, suggesting an allopolyploid origin. In both specimens mostly bivalents were observed. In *Spies 1485*, multivalent formation was rarely observed, but in *Spies 2642* only rod and ring bivalents were observed, evidence of allopolyploidy. The formation of mainly bivalents indicates an allopolyploid or segmental allopolyploid origin, thus suggesting a hybrid origin for this monotypic genus.

Danthonoideae

TABLE 2.—Genomic relationships in tetraploid *Styppeiochloa* specimens analysed according to Kimber & Alonso (1981). Values indicated represent the sums of squares calculated for the four possible tetraploid models. x-values are indicated in parentheses. Model best suited for each specimen is indicated in bold

Voucher no.	Chiasma frequency	4:0:1 mode	3:1 model	2:2 model	2:1:1 model
<i>Spies 1485</i>	0.86	3.688	3.973 (0.9485)	<b>0.416 (0.829)</b>	0.458 (0.9389)
<i>Spies 2642</i>	0.81	6.570	7.135 (0.92)	<b>0.000003 (1)</b>	1.835 (1)

A single specimen of *Chaetobromus involucratus* subsp. *dregeanus* was investigated with n = x = 6. This confirms a basic chromosome number of six for this genus, endemic to the semi-arid and arid western Cape region of South Africa and the extreme southwestern corner of Namibia (Du Plessis & Spies 1988; Spies & Du Plessis 1988; Spies *et al.* 1990; Verboom & Linder 1997). Studies of the genus *Chaetobromus* by Spies *et al.* (1990) suggested a polyploid complex, ranging from diploid to duodecaploid. Polyploidy occurs as segmental allopolyploidy or occasionally as allopolyploidy (Spies *et al.* 1990). Spies *et al.* (1990) reported on extensive morphological, cytogenetical and anatomical variation in *Chaetobromus*, indicating hybridization and polyploidy.



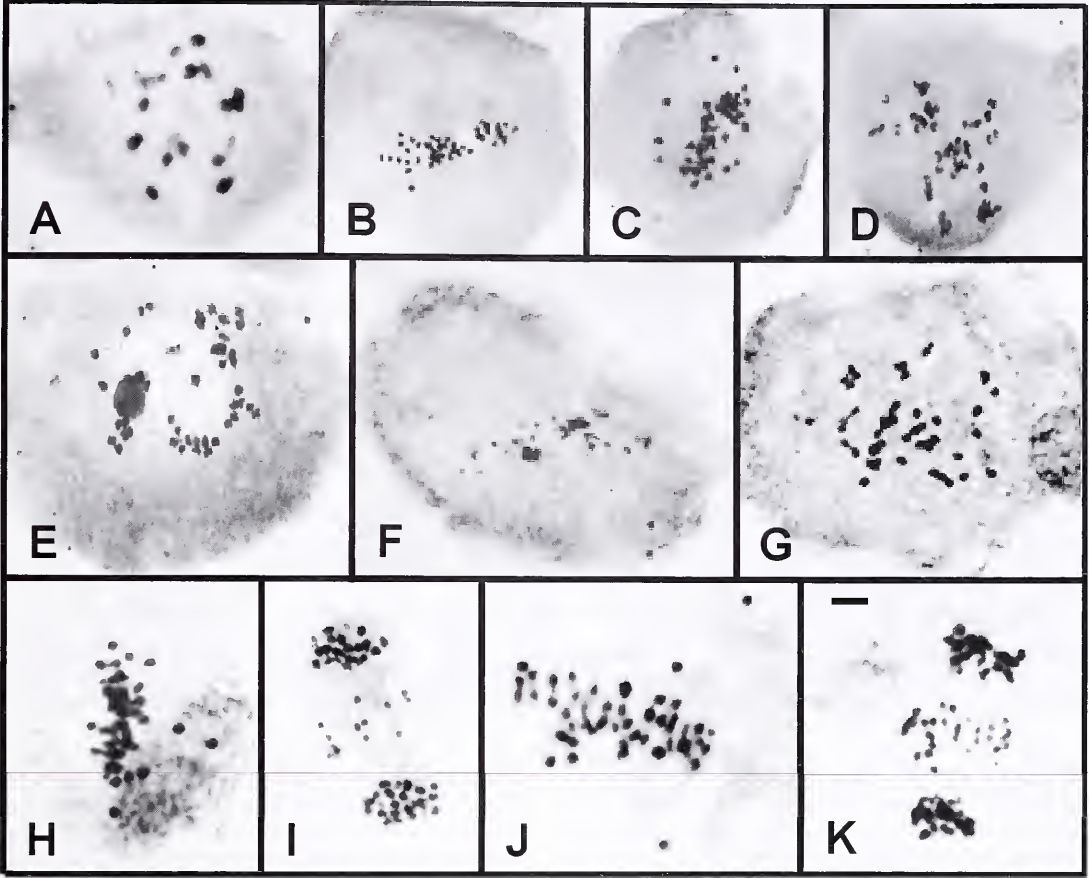


FIGURE 2.—Meiotic chromosomes in *Merxmuellera*. A, *M. cincta*, Spies 3504,  $2n = 6x = 36$ , diakinesis with  $18\mu$ , three bivalents are not in focus on this photograph. B, C, *M. decora*: B, Spies 4407,  $2n = 8x = 48$ , metaphase I; C, Spies 4458,  $2n = 8x = 48$ , metaphase I. D, *M. drakensbergensis*, Spies 4687,  $2n = 6x = 36$ , early anaphase I 18-18 segregation; E, *M. lupulina*, Spies 4601,  $2n = 8x = 48$ , diakinesis with  $24\mu$ ; F, *M. macowanii*, Spies 4727,  $2n = 8x = 48$ , metaphase I; G, *M. rufa*, Spies 4402,  $2n = 8x = 48$ , diakinesis. H–K, *M. stricta*, Spies 3140,  $2n = 9x = 54$ : H, J, metaphase I with various univalents; I, K, anaphase I with numerous laggards. Scale bar: A, E, F, G, J,  $5\mu$ ; B, C, D, H, I, K,  $9\mu$ .

Diploid chromosome numbers ( $n = x = 6$ ) were observed for all of the *Karroochloa* specimens studied, (Figure 1B–H) namely *Karroochloa curva*, *K. schismoides* and *K. tenella*. One *K. curva* specimen was studied cytogenetically and a low percentage of univalents (Spies 4518, Figure 1B) was observed. Two to five B chromosomes were observed in a single *K. purpurea* specimen (Spies 2473, Figure 1C, D) and this was also the only tetraploid specimen found. Further *K. purpurea* specimens exhibited normal meiosis (Figure 1E, F). In *K. chismoides* meiosis was normal (Figure 1F, H), but cell fusion was observed in some specimens (Spies 3382, Figure 1G) which could lead to polyploidy. The basic chromosome number of six was confirmed for this genus (Du Plessis & Spies 1988; Spies & Du Plessis 1988).

Chromosome numbers are reported for eight of the 18 southern African species of the genus *Merxmuellera*. The genus has a basic chromosome number of six (Du Plessis & Spies 1988; Spies & Du Plessis 1988). A single *M. cincta* specimen was investigated and found to be hexaploid (Figure 2A). All three *M. decora* specimens were octaploid ( $n = 4x = 24$ ) (Figure 2B, C). Meiosis was

abnormal with a high percentage of laggards during anaphase I (Figure 2C) and micro-nuclei during telophase I. In *M. disticha* meiosis was very abnormal with a high percentage of univalents during metaphase I, anaphase I laggards and micro-nuclei. This is the first report for *M. drakensbergensis*, both specimens being hexaploid ( $n = 3x = 18$ ) (Figure 2D). Only one *M. lupulina* specimen was investigated for the first time with  $n = 4x = 24$  (Figure 2E). All four *M. macowanii* specimens were octaploid (Figure 2F). An octaploid chromosome count for *M. rufa* is a first for this species (Figure 2G). Several multivalents are evident in various cells of this specimen. A large number of the specimens were *M. stricta*. Mostly tetraploid and hexaploid numbers, or deviations thereof, (Spies 3140,  $2n = 6x = 51$ ) (Figure 2H–K) were evident. Meiotic irregularities such as univalents (Figure 2H, J), laggards (Figure 2I, K) and micro-nuclei as well as cytomixis were observed. This abnormal meiotic behaviour in the genus and especially *M. stricta* would suggest these specimens to be of hybrid origin. Many *M. stricta* specimens were found to contain a high number of chromosomal laggards, and it is a variable perennial species.

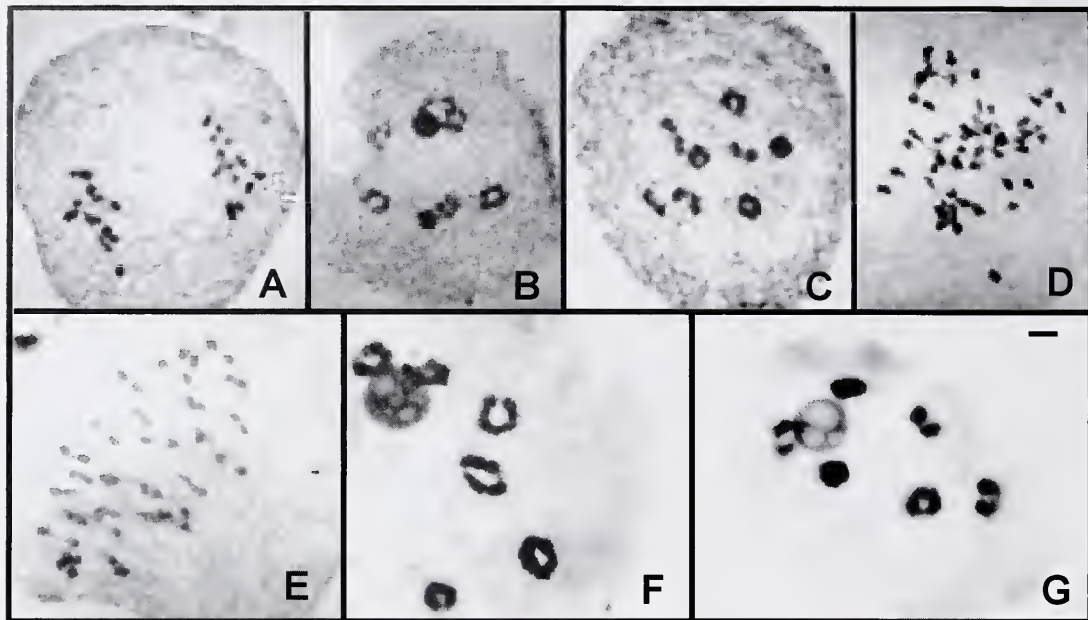


FIGURE 3.—Meiotic chromosomes in *Pentaschistis* and *Pseudopentameris*. A, *Pentaschistis pallida*, Spies 6208,  $2n = 4x = 28$ , anaphase I with 14–14 segregation; B, *P. rigidissima*, Spies 6243,  $2n = 2x = 14$ , diakinesis with  $7_{II}$ ; C, *P. tomentella*, Spies 6344,  $2n = 2x = 14+0-2B$ , diakinesis with  $7_{II}$ ; D, E, *P. tortuosa*, Spies 6214,  $2n = 8x = 56$ , early anaphase I with chromosomes starting to segregate. F, G, *Pseudopentameris macrantha*, Spies 3431,  $2n = 2x = 12$ , diakinesis with  $6_{II}$  in each cell. Scale bar: B, F, G, 6  $\mu$ m; A, C–E, 10  $\mu$ m.

Chippindall (1955) states that ‘There is considerable variation in the plants referred to as *Danthonia stricta* (*M. stricta*), and it is possible that they comprise more than one variety’. Ellis (1980) divided *M. stricta* into four ‘forms’: the ‘typical form’ (*M. stricta*), the ‘Drakensberg form’ (*M. stricta*), the ‘Cathedral Peak form’ (*M. guillarmodiae* Conert) and the ‘alpine form’ (*M. guillarmodiae*). Each of these forms exhibits distinct epidermal structure and leaf anatomy. In the Drakensberg region, two *Pentaschistis* species displayed remarkable anatomical similarities with *M. stricta*. These are *Pentaschistis tysonii* Stapf and an unnamed *Pentaschistis* species. Anatomically they seem to show greater affinity with the *M. stricta* group than with *Pentaschistis* (Ellis 1980). This raises the issue as to whether hybridization occurred, or is still occurring between the different *M. stricta* forms, or between the *Pentaschistis* species and *M. stricta*, and whether this could clarify the possible hybrid nature of *M. stricta*.

One diploid *Pentameris thuarii* specimen was studied ( $n = x = 7$ ). This confirms a basic chromosome number of seven for the genus (Spies & Roodt 2001).

In the genus *Pentaschistis*, 14 of the 57 indigenous south African species (Gibbs Russell *et al.* 1990) were studied. This is the first report for numbers in *P. acinosa* ( $n = x = 7$ ), *P. galpinii* ( $n = x = 7$ ) and *P. veneta* ( $n = 2x = 14$ ). Diploidy was observed in 21 of the 39 specimens (Figure 3B, C). Polyploidy is frequently encountered in *Pentaschistis*. In the study by Du Plessis & Spies (1992), 59% of the species investigated were polyploid, or had different polyploid levels. In this study tetraploidy was observed in *P. airoides*, *P. pallida* (Spies 5737, 5917, 6208) (Figure 3A), *P. tomentella* (Spies 5301, 5738), *P. veneta* and *P. viscidula*. Hexaploid

(*P. rupestris*), octaploid (*P. densifolia*, *P. lima*, *P. tortuosa*) (Figure 3D, E), decaploid (*P. rupestris*, *P. viscidula*) and up to 14-ploid levels (*P. rupestris*) were also observed. Higher ploidy levels in some cells of specimens can be caused by cell fusion (Spies & Van Wyk 1995). It is not an uncommon phenomenon in this genus.

Polyploidy is frequent in *Pentaschistis*. Klopper *et al.* (1998) reported on the existence of young polyploid complexes in 17 species. Twelve species were found to be old polyploid complexes, but were not adequately studied and the age of the complexes should be verified. Furthermore, Klopper *et al.* (1998) suggest that the genus *Pentaschistis* is a young polyploid hybrid complex.

B chromosomes were mostly encountered at the diploid level (33% of the diploid specimens having 1 to 4 B chromosomes present in some cells). In *Pentaschistis*, the number of B chromosomes per cell varied within the same species and even within the same specimen. This is evident in *P. curvifolia* (Spies 4456, 6169, 6236, 6315) where the number of B chromosomes varied from 0–4 in the different specimens. B chromosomes were also encountered in the tetraploid *P. viscidula* specimen (0–2B) but were absent from higher polyploid levels.

Only four genera, namely *Merxmüllera*, *Pentameris*, *Pentaschistis* and *Prionanthium* Desv., share the basic chromosome number of seven. Davidse *et al.* (1986) suggested that  $x = 7$  is a primitive number, as in the genus *Pentaschistis*, and that  $x = 13$ , which also occurs in the genus, was secondarily derived through an aneuploid reduction from  $x = 14$ . In this study no specimens with a basic chromosome number of 13 were observed.



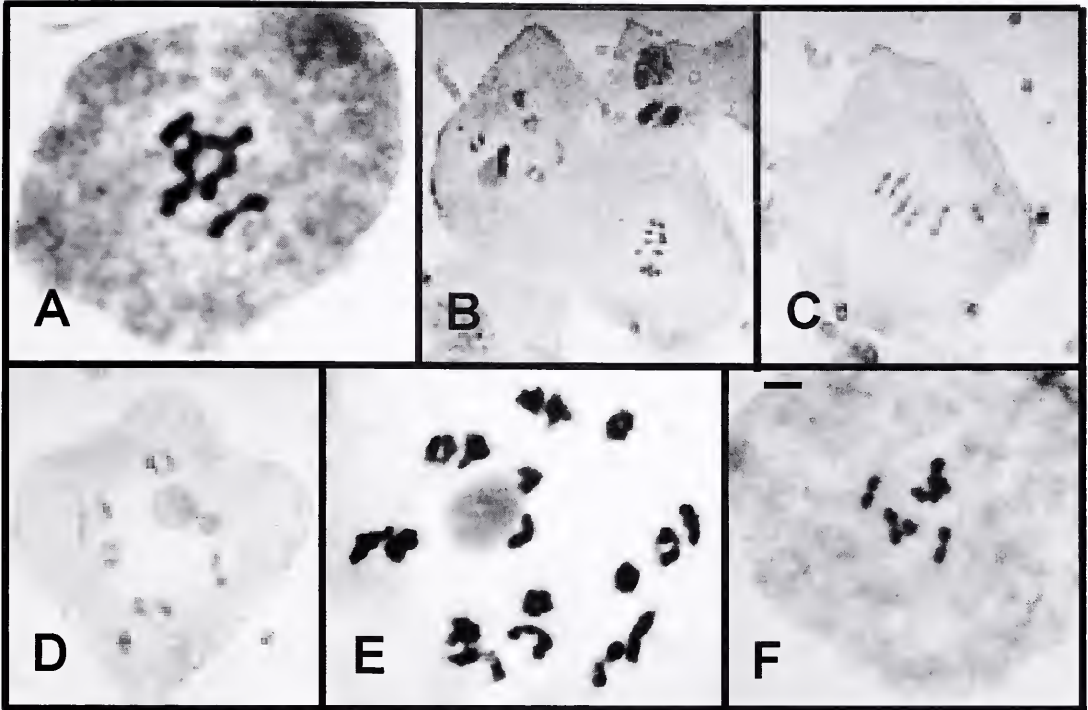


FIGURE 4.—Meiotic chromosomes in *Schismus* and *Tribolium*. A, *S. barbatus*, Davidse 34033,  $2n = 2x = 12$ , early metaphase I. B–D, *S. scaberimus*: B, C, Spies 4660,  $2n = 2x = 12$ , metaphase I; D, Spies 4661,  $2n = 2x = 12$ , diakinesis with  $6n$ . E, *T. obtusifolium*, Davidse 34049,  $2n = 6x = 36$ , diakinesis with  $18n$ ; F, *T. pusillum*, Davidse 34022,  $2n = 2x = 12$ , diakinesis with  $6n$ . Scale bar: A, F, 5  $\mu\text{m}$ ; B–E, 10  $\mu\text{m}$ .

One single specimen in the genus *Pseudopentameris* is reported here for the first time, *P. macrantha* with  $2n = 2x = 12$  (Figure 3F, G), and a basic chromosome number of six for the genus.

Three of the four endemic *Schismus* species were investigated cytogenetically. With the exception of a single *S. inermis* specimen (Davidse 33804), all the specimens were diploid,  $2n = 2x = 12$ , (Figure 4A–D) and confirms the basic chromosome number of six for the genus (Du Plessis & Spies 1988; Spies & Du Plessis 1988).

Du Plessis & Spies (1988) reported a polyploid complex in *Schismus barbatus*, based on the meiotic behaviour of one diploid, three tetraploid and one hexaploid specimen. However, all 14 *S. barbatus* specimens of this study were diploid.

The genus *Tribolium* was thoroughly investigated cytogenetically over the last couple of years (Spies *et al.* 1992; Visser & Spies 1994a–e). It was concluded that six is the basic chromosome number for the genus. Six additional specimens representing five species were investigated. Diploidy  $2n = 2x = 12$  was encountered in the species *T. hispidum* and *T. pusillum* (Figure 4F). *Tribolium acutiflorum*, *T. hispidum* and *T. uniola* were found to be tetraploid and a single hexaploid specimen, *T. obtusifolium* was found (Figure 4E). We and Visser & Spies (1994b) found diploid and tetraploid specimens in *T. hispidum*. In *Tribolium* polyploidy is common. This led Visser & Spies (1994b, d, e) to conclude that the genus *Tribolium* is a polyploid complex. Visser & Spies

(1994d) reported on a *T. uniola* hybrid swarm in which polyploidy is frequent and various meiotic abnormalities occur. 0–2 B chromosomes were observed, but only in the single *T. uniola* specimen.

The basic chromosome numbers of six and seven for the Danthonioideae and six for *Stypeiochloa* (Arundinoideae) is confirmed.

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#### CHROMOSOME STUDIES ON AFRICAN PLANTS. 18. THE SUBFAMILY CHLORIDOIDEAE

The subfamily Chloridoideae comprises  $\pm 150$  genera and 1 360 species and occurs mainly in arid regions (Hilu & Alice 2001). The plants probably originated in Africa (Hartley 1964), hence the great representation of the subfamily in Africa and especially southern Africa, with  $\pm 51$  genera and 235 species (Gibbs Russell *et al.* 1990). It is currently divided into five tribes by the Grass Phylogeny Working Group (GPWG 2001): Cynodonteae Dumort., Eragrostideae Stapf, Leptureae Dumort., Orcuttieae Reeder and Pappophoreae Kunth. The genus *Centropodia* Reich. and the species *Merxmüllera rangei* (Pilg.) Conert, previously included in the Arundinoideae, are now included in the Chloridoideae. They have not previously been included in any of the recognized tribes (GPWG 2001).

The aim of this study is to investigate chromosome numbers, meiotic chromosome behaviour and polyploid levels of some southern African representatives of this subfamily.

#### MATERIALS AND METHODS

Cytogenetic material of identical plants of a population was collected and fixed in the field. Voucher specimens, listed in Table 3, are housed in the Geo Potts Herbarium, Department of Plant Sciences, University of the Free State, Bloemfontein (BLFU), or in the National Herbarium, Pretoria (PRE).

Anthers were squashed in aceto-carmin and meiotically analysed (Spies *et al.* 1996)—at least 20 cells per meiot-

ic stage were studied. Only gametic chromosome numbers are presented to conform to previous papers on chromosome numbers in this journal (Spies & Du Plessis 1986).

#### RESULTS AND DISCUSSION

Seventy-nine plants, representing 42 species and 19 genera, were studied (Table 3). They represent three of the recognized tribes, namely Cynodonteae, Eragrostideae and Pappophoreae, as well as the unplaced genus *Centropodia*.

#### Tribe Cynodonteae

In the genus *Chloris* Sw., a single *C. virgata* specimen was investigated and found to be diploid ( $n = x = 10$ )

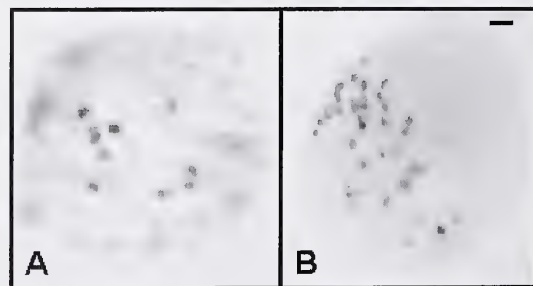


FIGURE 5.—Meiotic chromosomes. A, *Chloris virgata*, Spies 6616,  $2n = 2x = 20$ , diakinesis with 20II; B, *Cynodon dactylon*, Spies 2549,  $2n = 4x = 36$ , metaphase I. Scale bar: 5  $\mu$ m.

TABLE 1.—Gametic chromosome numbers (n) of representatives of subfamily Chloridoideae (Poaceae) in southern Africa with their voucher specimen numbers and specific localities. Species listed alphabetically and localities presented according to Edwards & Leistner (1971)

Taxon	n	Voucher	Locality
<b>Cynodonteae</b>			
<i>Chloris virgata</i> Sw.	10	<i>Spies 6616</i>	FREE STATE.—2827 (Senekal): 20 km from Senekal to Rosendal, (–BD).
<i>Cynodon dactylon</i> (L.) Pers.	18	<i>Spies 2549</i>	SWAZILAND.—2631 (Mbabane): 18 km northeast of Mbabane, (–AC).
	18	<i>Spies 2966</i>	NORTHERN CAPE.—2816 (Oranjemund): Alexander Bay, (–DA).
<i>Enteropogon macrostachyus</i> (A.Rich.) Benth.	10	<i>Venter 9339</i>	NAMIBIA.—1913 (Sesfontein): Sesfontein, Kaokoland, (–BB).
<i>Harpochloa falx</i> (L.f.) Kuntze	18	<i>Spies 5113</i>	MPUMALANGA.—2530 (Lydenburg): 5 km from Belfast to Dullstroom, (–CA).
	18	<i>Spies 5065</i>	FREE STATE.—2729 (Volksrust): 92 km from Harrismith to Normandien Pass, (–DC).
	18	<i>Spies 5078</i>	FREE STATE.—2729 (Volksrust): 97 km from Harrismith to Normandien Pass, (–DC).
	18	<i>Spies 6629</i>	FREE STATE.—2827 (Senekal): 33 km from Senekal to Rosendal, (–BD).
	18	<i>Spies 3986</i>	EASTERN CAPE.—3027 (Lady Grey): 45 km from Barkly East to Rhodes, (–DD).
	18	<i>Spies 4729</i>	EASTERN CAPE.—3027 (Lady Grey): 52 km from Rhodes via Lundean’s Neck, (–DD).
	18	<i>Spies 4691</i>	EASTERN CAPE.—3027 (Lady Grey): 47 km from Rhodes via Naude’s Neck, (–CC).
	18	<i>Spies 4695</i>	EASTERN CAPE.—3027 (Lady Grey): 65 km from Rhodes to Maclear via Naude’s Neck, (–CC).
	18	<i>Spies 6955</i>	EASTERN CAPE.—3027 (Lady Grey): 39 km from Barkly East to Rhodes, (–DD).
	27	<i>Spies 5125</i>	MPUMALANGA.—2530 (Lydenburg): 16 km from Dullstroom to Lydenburg via Frischgewaagd, (–AC).
	27	<i>Spies 5128</i>	MPUMALANGA.—2530 (Lydenburg): Nederhorst turn-off on Lydenburg-Roosenekal road, (–AA).
	27	<i>Spies 4712</i>	EASTERN CAPE.—3128 (Umtata): 38 km from Maclear to Elliott, (–AC).
<i>Tragus</i> sp.	10	<i>Spies 4803</i>	FREE STATE.—2827 (Senekal): 6 km from Clocolan to Peka bridge, (–DC).
<b>Eragrostideae</b>			
<i>Bewisia biflora</i> (Hack.) Gooss.	20	<i>Spies 1531</i>	MPUMALANGA.—2530 (Lydenburg): Steenkampsberg, (–AA).
<i>Cladoraphis cyperoides</i> (Thunb.) S.M.Phillips	10	<i>Spies 5704</i>	NORTHERN CAPE.—2816 (Oranjemund): 46 km from Bloeddrift to Alexander Bay, (–CB).
	10	<i>Spies 4894</i>	NORTHERN CAPE.—2917 (Springbok): 135 km from Springbok to Kleinsee, (–CA).
	10	<i>Spies 4889</i>	NORTHERN CAPE.—2917 (Springbok): 84 km from Springbok to Kleinsee, (–CA).
	10	<i>Spies 5356</i>	WESTERN CAPE.—3118 (Vanrhynsdorp): 21 km from Doorn Bay to Donkin Bay, (–CD).
<i>C. spinosa</i> (L.f.) S.M.Phillips	20	<i>Spies 4885</i>	NORTHERN CAPE.—2917 (Springbok): 82 km from Springbok to Kleinsee, (–CA).
<i>Dactyloctenium aegyptium</i> (L.) Willd.	20	<i>Spies 2403</i>	KWAZULU-NATAL.—2832 (Mtubatuba): 22 km from Cape Vidal to St Lucia, (–AD).
<i>Eleusine coracana</i> (L.) Gaertn. subsp. <i>africana</i> (Kenn.-O’Byrne) Hilu & De Wet	9	<i>Spies 2365, 2366</i>	KWAZULU-NATAL.—2832 (Mtubatuba): Cape Vidal, (–BA).
	18	<i>Spies 2783</i>	WESTERN CAPE.—3118 (Vanrhynsdorp): Koekenaap, irrigation scheme, (–CB).
<i>Eragrostis barbinodis</i> Hack.	20	<i>Spies 3317</i>	NORTHERN PROVINCE.—2428 (Nylstroom): Soutpan, (–CD).
<i>E. capensis</i> (Thunb.) Trin.	10	<i>Spies 4696</i>	EASTERN CAPE.—3027 (Lady Grey): 65 km from Rhodes via Naude’s Neck, (–CC).
	20	<i>Spies 1595</i>	MPUMALANGA.—2530 (Lydenburg): 41 km from Lydenburg to Roosenekal, (–AB).
	20	<i>Spies 5069</i>	FREE STATE.—2729 (Volksrust): 92 km from Harrismith to Normandien Pass, (–DC).
	20	<i>Du Plessis 110</i>	KWAZULU-NATAL.—2931 (Stanger): Balito Bay to Umhlali, (–AC).
	20	<i>Spies 3483</i>	EASTERN CAPE.—3325 (Port Elizabeth): 2 km from Rocklands to Elands River, (–CD).
	20	<i>Spies 3498</i>	EASTERN CAPE.—3424 (Humansdorp): 4 km from Humansdorp to Cape St. Francis, (–BB).
	20	<i>Davidse 33552</i>	Locality unknown.
<i>E. chloromelas</i> Steud.	20	<i>Spies 6947</i>	EASTERN CAPE.—3027 (Lady Grey): 35 km from Aliwal North to Lady Grey, (–CA).
<i>E. ciliaris</i> (L.) R.Br.	10	<i>Du Plessis 111</i>	KWAZULU-NATAL.—2931 (Stanger): Balito Bay to Umhlali, (–AC).
<i>E. curvula</i> (Schrad.) Nees	30	<i>Spies 1137</i>	EASTERN CAPE.—3225 (Somerset East): 35 km from Somerset East to Pearston, (–CB).
<i>E. echinochloidea</i> Stapf	20	<i>Spies 2799, 2800</i>	NORTHERN CAPE.—3018 (Kamiesberg): 3 km from Bitterfontein to Garies, (–DB).
<i>E. heteromera</i> Stapf	20	<i>Spies 2634</i>	SWAZILAND.—2631 (Mbabane): 80 km from Manzini to Lomahasha, (–BA).
<i>E. inamoena</i> K.Schum.	20	<i>Spies 2392</i>	KWAZULU-NATAL.—2832 (Mtubatuba): 12 km from Cape Vidal to St Lucia, (–AD).
<i>E. obtusa</i> Munro ex Ficalho & Hiern.	10	<i>Spies 2886</i>	NORTHERN CAPE.—2823 (Griekwastad): 16 km from Griekwastad to Kimberley, (–CD).
<i>E. planiculmis</i> Nees	30	<i>Spies 1116</i>	EASTERN CAPE.—3225 (Somerset East): Daggaboersnek Pass, Cookhouse to Cradock, (–DB).
<i>E. racemosa</i> (Thunb.) Steud.	20	<i>Spies 5066</i>	FREE STATE.—2729 (Volksrust): 92 km from Harrismith to Normandien Pass, (–DC).

TABLE 1.—Gametic chromosome numbers (n) of representatives of subfamily Chloridoideae (Poaceae) in southern Africa with their voucher specimen numbers and specific localities. Species listed alphabetically and localities presented according to Edwards & Leistner (1971) (cont.)

Taxon	n	Voucher	Locality
<i>E. racemosa</i> (Thunb.) Steud.	20	<i>Spies 3279</i>	KWAZULU-NATAL.—2829 (Harrismith): Windy Corner, Van Reenen, (–AD).
	20	<i>Spies 4743</i>	EASTERN CAPE.—3027 (Lady Grey): 15 km from Barkly East to Lady Grey, (–CD).
<i>E. sclerantha</i> Nees subsp. <i>sclerantha</i>	20	<i>Spies 4844</i>	FREE STATE.—2828 (Bethlehem): 19 km from Fouriesburg to Clarens, (–CA).
<i>E. superba</i> Peyr.	20	<i>Spies 3326</i>	NORTHERN PROVINCE.—2428 (Nylstroom): Soutpan, (–CD).
	20	<i>Du Plessis 136</i>	KWAZULU-NATAL.—2830 (Dundee): 5 km from Muden to Greytown, (–DC).
<i>E. tef</i> (Zucc.) Trotter	20	<i>Spies 2405</i>	KWAZULU-NATAL.—2832 (Mtubatuba): 22 km from Cape Vidal to St Lucia, (–AD).
<i>E. tenuifolia</i> (A.Rich.) Steud.	10	<i>Spies 2595</i>	SWAZILAND.—2631 (Mbabane): Siteki, (–BD).
<i>E. trichophora</i> Coss. & Dur.	20	<i>Spies 2774</i>	WESTERN CAPE.—3118 (Vanrhynsdorp): 3 km from Lutzville to Koekenaap, (–CB).
<i>Fingerhuthia africana</i> Lehm.	20	<i>Spies 2947</i>	NAMIBIA.—2618 (Keetmanshoop): Remshoogte, Annisfontein, (–BD).
	20	<i>Spies 4349</i>	WESTERN CAPE.—3118 (Vanrhynsdorp): 35 km from Vanrhynsdorp to Nieuwoudtville, (–DA).
<i>Leptochloa fusca</i> (L.) Kunth.	10	<i>Spies 4875</i>	NORTHERN CAPE.—2917 (Springbok): 7 km from Springbok to Kleinsee, (–DB).
	10	<i>Spies 2991A</i>	NORTHERN CAPE.—3017 (Hondeklipbaai): 5 km east of Kamieskroon, (–BB).
	10	<i>Spies 3037</i>	NORTHERN CAPE.—3017 (Hondeklipbaai): 12 km east of Hondeklipbaai, (–AD).
	10	<i>Spies 4316</i>	NORTHERN CAPE.—3018 (Kamiesberg): 35 km from Leliefontein to Garies, (–AB).
	10	<i>Spies 3794</i>	WESTERN CAPE.—3118 (Vanrhynsdorp): Gifberg, (–CB).
	10	<i>Spies 5200</i>	WESTERN CAPE.—3324 (Steytlerville): 34 km from Patensie to Willowmore, (–DD).
	10	<i>Spies 3932</i>	WESTERN CAPE.—3419 (Caledon): McGregor FM tower, Riviersonderend Mountain, (–BA).
	10	<i>Davidse 33407</i>	Locality unknown.
<i>Odyssea paucinervis</i> (Nees) Stapf	18	<i>Spies 3384</i>	NORTHERN CAPE.—3017 (Hondeklipbaai): Groen River mouth, (–DC).
<i>Sporobolus africanus</i> (Poir.) Robyns & Tournay	9	<i>Spies 4508</i>	WESTERN CAPE.—3420 (Bredasdorp): 1.4 km from De Hoop Nature Reserve, (–AD).
	18	<i>Spies 2369</i>	KWAZULU-NATAL.—2832 (Mtubatuba): Cape Vidal, (–BA).
<i>S. albicans</i> Nees	27	<i>Spies 3141</i>	WESTERN CAPE.—3220 (Sutherland): 15 km from Sutherland to Matjiesfontein, Verlatenkloof, (–BC).
<i>S. ioclados</i> (Trin.) Nees	9	<i>Spies 3171</i>	WESTERN CAPE.—3218 (Clanwilliam): 1 km from Sauer to Velddrif, (–DC).
<i>S. virginicus</i> (L.) Kunth	9	<i>Du Plessis 122</i>	KWAZULU-NATAL.—2931 (Stanger): Tongaat River, on beach near bridge, (–CA).
<i>Stiburnus alopecuroides</i> (Hack.) Stapf	10	<i>Spies 1470</i>	MPUMALANGA.—2530 (Lydenburg): Steenkampsberg, 18 km from Dullstroom to Goede Hoop, (–AC).
<i>S. conrathii</i> Hack.	10	<i>Du Plessis 19</i>	MPUMALANGA.—2530 (Lydenburg): 19 km from Lydenburg to Weltevreden, (–AB).
<i>Trichoneura</i> sp.	10	<i>Spies 4833</i>	FREE STATE.—2827 (Senekal): 6 km from Nebo to Fouriesburg via Generaalsnek, (–DB).
<b>Pappophoreae</b>			
<i>Enneapogon cenchroides</i> (Roem. & Schult.) C.E.Hubb.	20	<i>Spies 3288</i>	NORTHERN PROVINCE.—2428 (Nylstroom): Soutpan at the crater, (–CD).
	30	<i>Spies 2709</i>	NORTHERN CAPE.—2924 (Hopetown): 31 km from Hopetown to Britstown, (–CA).
<i>E. pretoriensis</i> Stent	10	<i>Spies 3716</i>	NORTH-WEST.—2527 (Rustenburg): 7 km from Hartbeeshoek turn-off between Muldersdrift and Hekpoort, (–DB).
<i>Enneapogon</i> sp.	20	<i>Spies 5532</i>	NORTH-WEST.—2725 (Bloemhof): 31 km from Vryburg to Schweizer-Reineke, (–AB).
<i>Schmidtia pappophoroides</i> Steud	18	<i>Du Plessis 186</i>	NORTHERN PROVINCE.—2329 (Pietersburg): 66 km from Pietersburg to Louis Trichardt, (–BB).
<i>Schmidtia</i> sp.	18+0-4B	<i>Spies 5536</i>	NORTH-WEST.—2624 (Vryburg): 36 km from Vryburg to Amalia, (–DC).
<b>Unplaced</b>			
<i>Centropodia glauca</i> (Nees) Cope	24	<i>Spies 5706</i>	NORTHERN CAPE.—2816 (Oranjemund): 46 km from Bloeddrift to Alexander Bay, (–DA).

(Figure 5A). This confirms the basic chromosome number of 10 for this genus (Darlington & Wylie 1955; Pienaar 1955; Ornduff 1967, 1968, 1969; Federov 1969; Moore 1970, 1971, 1972, 1973, 1974, 1977; Goldblatt 1981, 1983, 1985, 1988; Goldblatt & Johnson 1990, 1991, 1998, 2000). Polyploid levels do occur in the genus and triploid and tetraploid numbers have been observed in South African specimens by previous authors (Moffet & Hurcombe 1949; De Wet 1954; Spies & Du Plessis 1987). The genus is known to contain many aneuploid deviations from the basic chromosome number of ten (Fish 2000), but none have been observed in

South African specimens before (Hunter 1934; Moffet & Hurcombe 1949; De Wet 1954; Spies & Du Plessis 1987; Spies & Jonker 1987; Strydom & Spies 1994).

*Cynodon dactylon* is an introduced species in tropical and warm temperate areas throughout the world, but is indigenous to southern Africa (Gibbs Russell & Spies 1988). Two specimens were investigated, both with  $2n = 4x = 36$  (Figure 5B). Tetraploidy is by far the most numerous polyploid level present in the genus (Darlington & Wylie 1955; Pienaar 1955; Ornduff 1968, 1969; Federov 1969; Moore 1970, 1972, 1973, 1974, 1977; Goldblatt



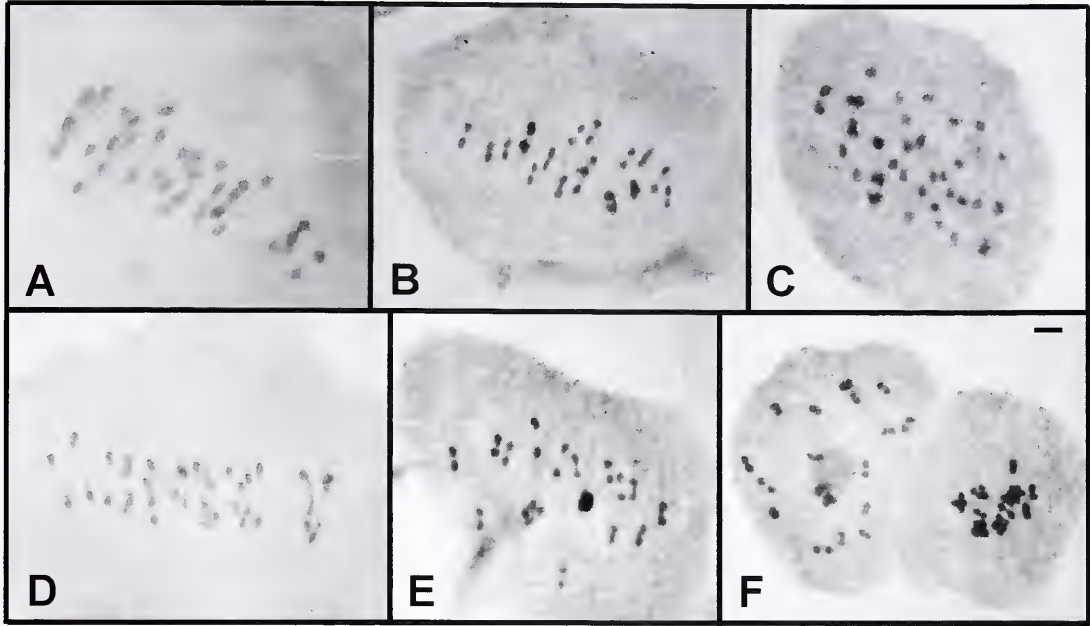


FIGURE 6.—Meiotic chromosomes in *Harpochloa falx*. A, *Spies 3986*,  $2n = 4x = 36$ , metaphase I; B, C, *Spies 4695*,  $2n = 4x = 36$ : B, metaphase I; C, desynapsis of bivalents during metaphase I. D, *Spies 4729*,  $2n = 4x = 36$ , metaphase I; E, *Spies 5113*,  $2n = 4x = 36$ , metaphase I; F, *Spies 6955*,  $2n = 4x = 36$ , diakinesis with  $18\mu$ . Scale bar: C, E,  $8\mu$ ; A, B, D, F,  $10\mu$ .

1981, 1983, 1985; Goldblatt & Johnson 1990, 1994, 1996, 1998). De Silva & Snaydon (1995) concluded that the differences in the polyploid level in *C. dactylon* could be related both to different climatic regions and different ecological habitats. The populations growing in arid, dry and intermediate regions were tetraploid and those from wetter regions consisted entirely of diploid plants. De Silva & Snaydon (1995) also related these polyploid levels to soil acidity and alkalinity (tetraploid = pH > 6.5; diploid = pH < 5.0). These findings might explain the predominance of tetraploidy in South Africa with its dryer, more arid regions. A basic chromosome number of  $x = 9$  is confirmed for this species and genus, although 10 has also been reported in a few instances (Ornduff 1968, 1969; Moore 1970, 1972, 1974, 1977; Goldblatt 1981, 1983, 1985; Goldblatt & Johnson 1990, 1994, 1996, 1998).

Chromosome numbers for the genus *Enteropogon* Nees have only been reported once and a basic chromosome number of 10 published for the genus (Darlington & Wylie 1955). One *E. macrostachyus* specimen investigated in this study was found to be tetraploid ( $n = 2x = 20$ ). This is the first report on a South African specimen in the genus, the previous one being from India.

Twelve specimens representing the species *Harpochloa falx* were studied. Nine of these were tetraploid and three were hexaploid. All specimens had multiples of nine ( $n = 2x = 18$ ;  $n = 3x = 54$ ) (Figure 6A–F). This represents a new basic chromosome number for this genus and could imply that *Harpochloa* also has two basic chromosome numbers (De Wet 1958; Spies & Du Plessis 1986; Spies *et al.* 1991; Strydom & Spies 1994). Furthermore, no known reports of any diploid specimens in the genus exist, which could indicate the existence of an older polyploid complex.

The genus *Tragus* Haller is widespread throughout the tropics, but mainly in Africa. It is especially common in disturbed areas (Clayton & Renvoize 1986; Fish 2000). One *Tragus* specimen was investigated and found to be diploid with  $n = x = 10$ . Only diploid, as in this study, or tetraploid chromosome numbers are known for this genus, based on a basic chromosome number of 10 (Darlington & Wylie 1955; Ornduff 1967, 1968, 1969; Federov 1969; Moore 1970, 1972, 1973, 1974, 1977; Goldblatt 1981, 1983, 1988; Goldblatt & Johnson 1990, 1994, 1998).

#### Tribe Eragrostideae

The genus *Bewsia* Gooss. is monotypic and a single *Bewsia biflora* specimen was investigated. This specimen was tetraploid ( $n = 2x = 20$ ) (Figure 7A), which confirms a basic chromosome number of ten, based on previous reports by De Wet & Anderson (1956) of  $2n = 3x = 30$  and Davidse *et al.* (1986) of  $2n = 45$  from Zimbabwe. Davidse *et al.* (1986) reported on very irregular meiosis in the particular specimen. Results presented in this study are the third known report for this genus.

*Cladoraphis* Franch. comprises two species *C. cyperoides* and *C. spinosa*. De Winter (1955) included this genus in *Eragrostis* Wolf, but later authors (Phillips 1982; Clayton & Renvoize 1986; Gibbs Russell *et al.* 1990; Watson & Dallwitz 1992) retained its separate generic status. It has a very specific habitat and occurs in sandy desert (*C. spinosa*) and coastal dunes (*C. cyperoides*) (Clayton & Renvoize 1986), mainly in the western regions of Namibia and Northern and Western Cape (Fish 2000). Five specimens were investigated representing both species. All four *C. cyperoides* specimens were diploid, with *C. spinosa* being tetraploid ( $n = 2x = 20$ ).

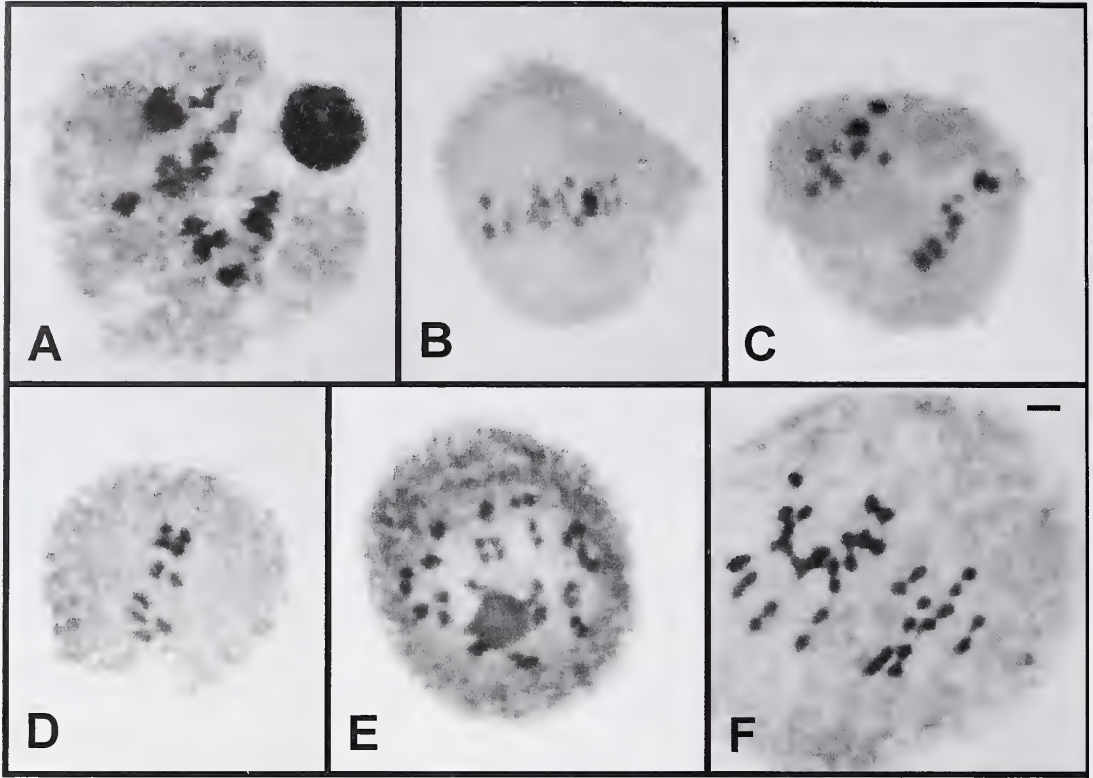


FIGURE 7.—Meiotic chromosomes. A. *Bewsia biflora*, *Spies 1531*,  $2n = 4x = 40$ , diakinesis with  $20_{II}$ , three chromosomes are not in focus on this photograph. B. C. *Cladoraphis cyperoides*, *Spies 4894*,  $2n = 2x = 20$ : B, metaphase I; C, anaphase I, 10-10 segregation. D. C. *cyperoides*, *Spies 5356*,  $2n = 2x = 20$ , diakinesis; E. C. *spinosa*, *Spies 4885*,  $2n = 4x = 40$ , diakinesis with  $20_{II}$ ; F. *Dactyloctenium aegyptium*, *Spies 2403*,  $2n = 4x = 40$ , metaphase I. Scale bar: 5  $\mu$ m.

(Figure 7B–E). This is, to the best of our knowledge, the first reports for chromosome numbers in this genus.

One specimen of the widespread tropical weed (Gould & Soderstrom 1974) *Dactyloctenium aegyptium* was investigated. It was found to be tetraploid ( $n = 2x = 20$ ) (Figure 7F). Three basic chromosome numbers are recorded for this genus,  $x = 9, 10, 12$  (Darlington & Wylie 1955 ( $x = 10, 12$ ); Pienaar 1955 ( $x = 9, 12$ ); Ornduff 1967 ( $x = 10$ ), 1968 ( $x = 12$ ); Moore 1971 ( $x = 9$ ), 1972 ( $x = 9$ ), 1977 ( $x = 12$ ); Goldblatt 1981 ( $x = 9, 10, 12$ ), 1983 ( $x = 9, 10, 12$ ), 1985 ( $x = 12$ ), 1988 ( $x = 9, 10$ ); Goldblatt & Johnson 1990 ( $x = 9, 10, 12$ ), 1991 ( $x = 10$ ), 1994 ( $x = 12$ ), 1998 ( $x = 10, 12$ ). This is one of the genera in the Chloridoideae (as is *Sporobolus*), with the most variation in basic chromosome number.

The generic status of *Diplachne* P.Beauv. has long been in doubt (McVaugh 1983; Peterson *et al.* 1997), with some authors preferring to unite this genus with the closely related genus *Leptochloa* P.Beauv. (McNeill 1979; Phillips 1982). These two genera have traditionally been kept distinct by Old World taxonomists where these genera are quite distinct, whereas the position of the genera from the Americas are very confused with intergrading taking place (Phillips 1982). For this study, the accepted name *Leptochloa* will be used.

Eight *Leptochloa fusca* specimens were investigated and all were diploid ( $n = x = 10$ ) (Figure 8A–E), which confirms the basic chromosome number of ten for this genus (Darlington & Wylie 1955; Ornduff 1968; Federov 1969; Moore 1977; Goldblatt & Johnson 1990, 1991, 1994, 1998). Previous studies have mostly reported tetraploids and this is the first study with such a large number of diploids. The specimens investigated were largely from Northern and Western Cape, and due to the widespread distribution of this species, the total variation present might not be represented.

*Eleusine* Gaertn. is predominantly an African genus, with six of the nine species confined to tropical and subtropical Africa (Phillips 1972). *Eleusine coracana* (L.) Gaertn. is widely grown in Africa, India and China, and used as a cereal. It is derived from *E. indica* (L.) Gaertn., a diploid cosmopolitan weed (subsp. *indica*,  $2n = 18$ ), which has a tetraploid race in Africa (subsp. *africana*). The morphological characters of the two races overlap greatly, and this leads to their inclusion in a single species (Clayton & Renvoize 1986). *Eleusine coracana* subsp. *africana* (= *E. indica* subsp. *africana*) is native to Africa, where it is widespread along the eastern highlands and the highlands of the southern African plateau (Phillips 1972).

Three *E. coracana* subsp. *africana* specimens were investigated. The two specimens from Cape Vidal were

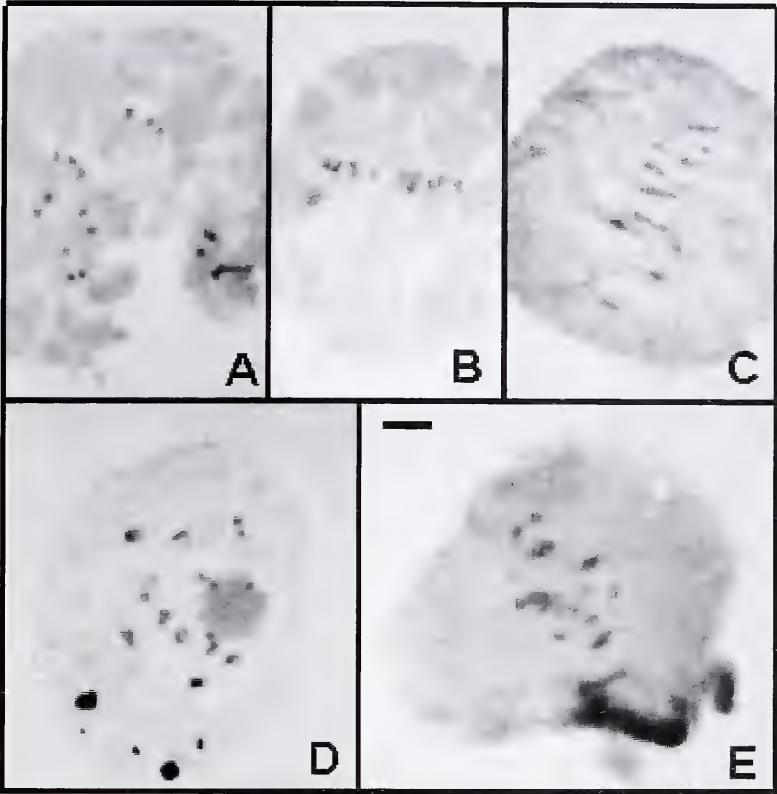


FIGURE 8.—Meiotic chromosomes in *Leptochloa fusca*. A, B, *Spies 3794*,  $2n = 2x = 20$ : A, anaphase I with 10-10 segregation; B, metaphase I. C, *Spies 3932*,  $2n = 2x = 20$ , metaphase I; D, *Spies 4316*,  $2n = 2x = 20$ , diakinesis with  $10_{II}$ ; E, *Spies 5200*,  $2n = 2x = 20$ , metaphase I. Scale bar: 5  $\mu$ m.

diploid (Figure 9A, B) and the specimen from Koeke-naap in Western Cape was tetraploid ( $n = 2x = 18$ ) (Figure 9C). This indicates that diploid and tetraploid forms of this species are present in South Africa and confirm a basic chromosome number of nine for this genus (Darlington & Wylie 1955; Pienaar 1955; Ornduff 1967, 1968, 1969; Federov 1969; Moore 1970, 1971, 1972, 1974, 1977; Goldblatt 1981, 1983, 1985, 1988; Goldblatt & Johnson 1990, 1991, 1994, 1998, 2000).

*Eragrostis* Wolf is the largest genus in the subfamily Chloridoideae. It has a worldwide occurrence in the warmer regions where it is found in most habitats, showing a preference for open sites, poor dry soil and weedy places (Clayton & Renvoize 1986). The genus exhibits the full range of morphological and anatomical variation found in the subfamily (Van den Borre & Watson 1994).

*Eragrostis* is the largest grass genus in southern Africa with  $\pm 90$  species. In this study 27 specimens were investigated, representing 17 species. Twenty of the specimens were tetraploid (Figure 10E, F, H). Only five

specimens investigated were diploid and two were hexaploid (Figure 10D, G). Polyploidy is frequent in this genus as can be seen from the results presented. Tetraploidy, as in this study, is the most frequent polyploid level observed, followed by diploidy (Darlington & Wylie 1955; Pienaar 1955; Ornduff 1967, 1968, 1969; Moore 1970, 1971, 1972, 1973, 1974, 1977; Goldblatt 1981, 1983, 1985, 1988; Goldblatt & Johnson 1990, 1991, 1994, 1998, 2000).

Seven specimens were investigated for *E. capensis*. All but one was tetraploid (Figure 10A–C). *Spies 4696* was diploid and is the second report for this species (De Wet 1958) where tetraploidy (Avdulov 1931; Pienaar 1953; Davidse *et al.* 1986; Spies & Du Plessis 1986; Spies *et al.* 1991) and hexaploidy (Moffet & Hurcombe 1949; Spies & Voges 1988) have previously been observed.

De Winter (1955) regards *E. curvula* as the most variable species in the genus in southern Africa, with a great many morphological forms. This was corroborated by large-scale cytogenetic studies by Vorster & Liebenberg

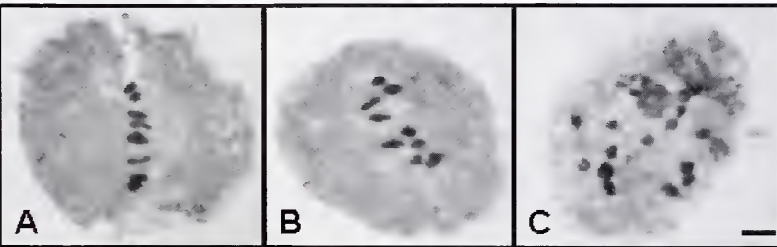


FIGURE 9.—Meiotic chromosomes in *Eleusine coracana* subsp. *africana*. A, B, *Spies 2365*,  $2n = 2x = 18$ , metaphase I; C, *Spies 2783*,  $2n = 4x = 36$ , diakinesis with  $18_{II}$ . Scale bar: 5  $\mu$ m.



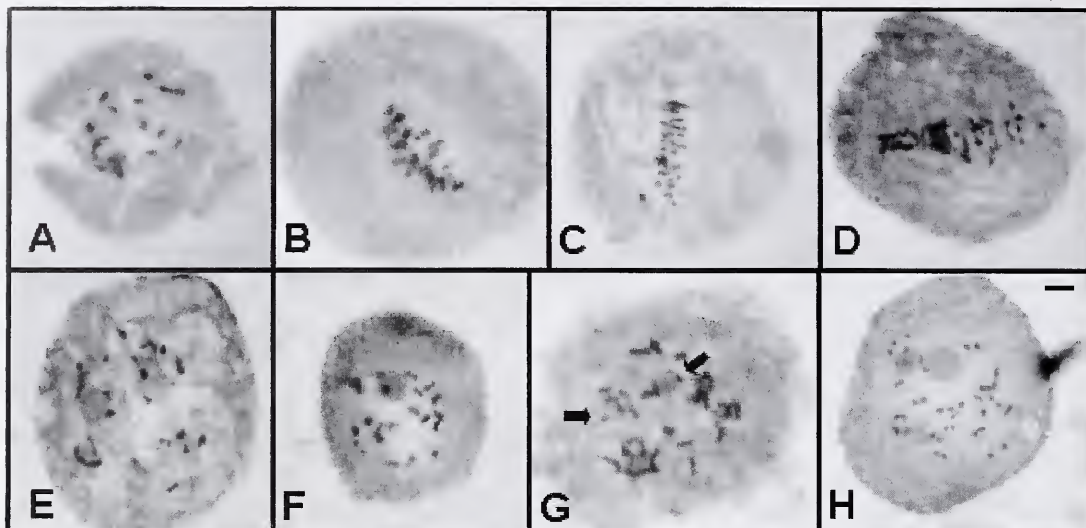


FIGURE 10.—Meiotic chromosomes. A–C, *Eragrostis capensis*: A, *Spies* 3483,  $2n = 4x = 40$ , diakinesis with  $20\mu$ ; B, *Spies* 3498,  $2n = 4x = 40$ , metaphase I; C, *Spies* 5069,  $2n = 4x = 40$ , metaphase I. D, *E. curvula*, *Spies* 1137,  $2n = 6x = 60$ ; E, *E. echinocloidea*, *Spies* 2799,  $2n = 4x = 40$ , diakinesis with  $20\mu$ ; F, *E. inamoena*, *Spies* 2392,  $2n = 4x = 40$ , diakinesis with  $20\mu$ ; G, *E. planiculmis*, *Du Plessis* 116,  $2n = 6x = 60+0-4B$ , diakinesis with  $30\mu$ , two B chromosomes are indicated; H, *E. superba*, *Du Plessis* 136,  $2n = 4x = 40$ , diakinesis with  $20\mu$ . Scale bar: B, G,  $10\mu$ ; A, C–F, H,  $12\mu$ .

(1977). Several species are known to intergrade with *E. curvula* through hybridization: *E. barbinodes*, *E. caesia* Stapf, *E. chloromelas*, *E. lehmaniana* Nees, *E. planiculmis* and *E. rigidior* Pilg. (Smook 1990). Proof of hybridization in this species indicates a collapse of isolating mechanisms between different species in the *Eragrostis curvula* complex, resulting in a large-scale hybrid swarm, with continuous variation of characters between parental extremes. The variation in morphological characters is an indication of the extent of hybridization (Spies 1984). Four specimens in this complex were cytogenetically investigated and tetraploid (*E. barbinodes* and *E. chloromelas*) and hexaploid (*E. curvula* and *E.*

*planiculmis*) levels were observed (Figure 10D, G). In all but *E. barbinodes*, various univalents were observed which resulted in laggards and later formed micronuclei. According to Church (1929), the presence of unpaired or univalent chromosomes is one of the most prominent suggestions that a plant is of hybrid origin (Church 1929) and therefore, in this complex with its large-scale hybridization, these phenomena will be very prevalent.

This is the third report for the species *E. heteromera* with  $2n = 4x = 40$  (De Wet 1958; De Wet 1960). As far as is known only two reports for *E. tef* exist (Avdulov

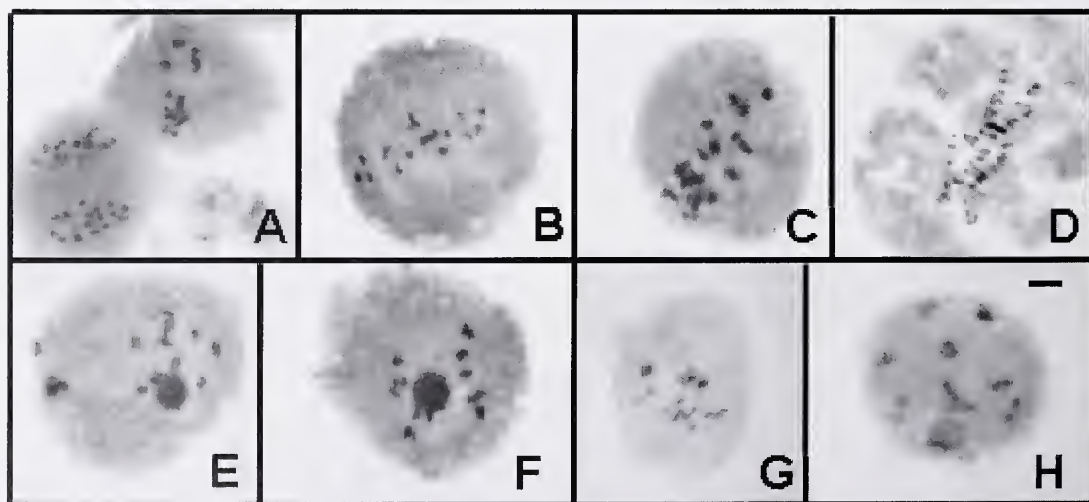


FIGURE 11.—Meiotic chromosomes. A, B, *Fingerhuthia africana*, *Spies* 2947,  $2n = 4x = 40$ : A, late anaphase I; B, metaphase I. C, *Sporobolus albicans*, *Spies* 3141,  $2n = 6x = 54$ , metaphase I; D, *S. africanus*, *Spies* 2369,  $2n = 4x = 36$ , metaphase I; E, F, *S. virginicus*, *Du Plessis* 122,  $2n = 2x = 18$ , diakinesis with  $10\mu$ ; G, H, *Stiburus conrathii*, *Du Plessis* 19,  $2n = 2x = 20$ : G, metaphase I; H, diakinesis with  $10\mu$ . Scale bar:  $8\mu$ .

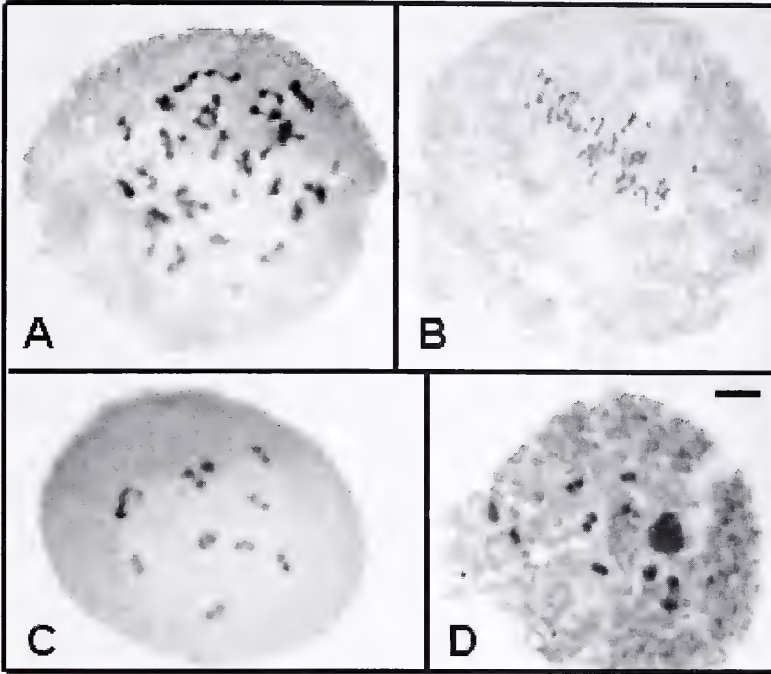


FIGURE 12.—Meiotic chromosomes in *Enneapogon*. A, B, *E. cenchroides*, Spies 2709,  $2n = 6x = 60$ : A, diakinesis with  $30\mu$ ; B, metaphase I. C, D, *E. pretoriensis*, Spies 3716,  $2n = 2x = 20$ , diakinesis with  $10\mu$ . Scale bar: A, C, D,  $5\mu$ ; B,  $8\mu$ .

1931; Moffet & Hurcombe 1949) and corroborates tetraploidy present in this species. Previously only tetraploid levels were observed in the species *E. tenuifolia* (Ornduff 1967; Moore 1973, 1977; Goldblatt 1983). Here we report on a diploid specimen from Siteki in Swaziland. Univalents were observed in some cells in this specimen. The tetraploid chromosome count for *E. trichophora* reported here is the second for the species (Davidse *et al.* 1986) and a hexaploid specimen was reported by Spies & Jonker (1987). One previous report of  $2n = 4x = 40$  for *E. racemosa* (Ornduff 1967) is confirmed in this study where three tetraploid specimens were found.

Two *Fingerhuthia africana* specimens were investigated and were tetraploid ( $n = 2x = 20$ ) (Figure 11A, B). Previous reports by Spies & Du Plessis (1987) and De Wet (1958, 1960) also found tetraploidy in the genus, but diploidy has been reported (De Wet 1958, 1960) as well.

*Odyssea* Stapf is a xerophytic grass genus with two species, one indigenous to southern Africa (Clayton & Renvoize 1986). It has a very distinct, much-branched, spiny habit, which is an adaptation to its specialized sandy and saline habitats (Phillips 1982). This is a first report for the genus. The specimen, *O. paucinervis*, was tetraploid ( $n = 2x = 18$ ) and, therefore the basic chromosome number is 9.

The genus *Sporobolus* R.Br. is cytogenetically complex and different basic chromosome numbers,  $x = 6, 9$  and  $10$  may be present (Davidse *et al.* 1986). Five *Sporobolus* species were investigated. Three diploid (*S. africanus*, Spies 4508, *S. ioclados*, *S. virginicus*), one tetraploid (*S. africanus*, Spies 2369) and one hexaploid (*S. albicans*) specimen were found (Figure 11C–F). They all displayed multiples of nine and this confirms  $x = 9$  as

the basic chromosome number for the genus (Darlington & Wylie 1955; Pienaar 1955; Ornduff 1967, 1968, 1969; Federov 1969; Moore 1970, 1971, 1972, 1973, 1974, 1977; Goldblatt 1981, 1983, 1985, 1988; Goldblatt & Johnson 1990, 1991, 1994, 1996, 1998). A chromosome number for *S. albicans* has not previously been published and this is the first report for the species (Figure 11F). Large-scale studies in this genus are still necessary to investigate the different basic chromosome numbers present and their possible phylogenetic relationships.

One specimen each of the two species *Stiburus alopecuroides* and *S. conrathii* was examined. Both were diploid ( $n = x = 10$ ) (Figure 11G, H) and this confirms chromosome counts based on multiples of 10 for the genus (Spies & Du Plessis 1986).

A single *Trichoneura grandiglumis* specimen was found with a chromosome count of  $n = x = 10$ . Moffet & Hurcombe (1949) and De Wet & Anderson (1956) also reported on diploid specimens.

#### Tribe Pappophoreae

The genus *Enneapogon* Desv. ex P.Beauv. is a very uniform genus in which most species (28 in total) closely resemble one another. Four specimens representing two species and one unidentified specimen were examined in this study (Figure 12A–D). One specimen, *Enneapogon cenchroides* was tetraploid with  $n = 2x = 20$ , but another specimen was hexaploid (Figure 12A, B). Spies 5532, the unidentified specimen, was also found to be tetraploid. A single *E. pretoriensis* specimen had  $n = x = 10$  (Figure 12C, D). Two basic chromosome numbers are reported for this genus,  $x = 9, 10$  (Darlington & Wylie ( $x = 9, 10$ ); Ornduff 1968 ( $x = 10$ ), 1969 ( $x = 10$ ); Moore 1970 ( $x = 10$ ), 1977 ( $x = 10$ );



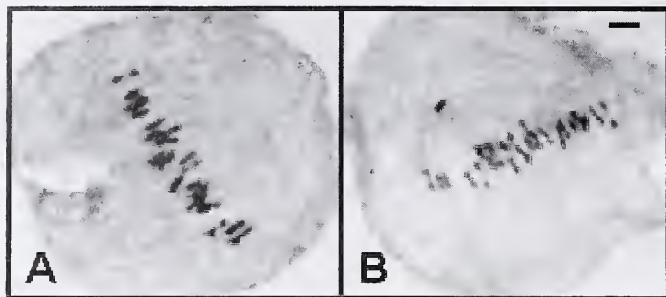


FIGURE 13.—Meiotic chromosomes in *Centropodia glauca*: A, B, *Spies 5706*,  $2n = 8x = 48$ , metaphase I. Scale bar: 8  $\mu$ m.

Goldblatt 1981 ( $x = 10$ ), 1985 ( $x = 10$ ); Goldblatt & Johnson 1991 ( $x = 10$ ), 1998 ( $x = 10$ ). The majority of the studies support a basic chromosome number of ten. Only three studies, De Wet (1954), Thomas unpublished (listed Darlington & Wylie 1955) and De Wet & Anderson (1956) ever reported  $x = 9$ . They found one diploid (De Wet & Anderson 1956) and five tetraploid (De Wet 1954; Thomas (Darlington & Wylie 1955); De Wet & Anderson 1956) specimens based on  $x = 9$ . Davidse *et al.* (1986) also reported on aneuploidy in the genus.

The genus *Schmidtia* Steud. ex J.A. Schmidt comprises only two species, both widespread in southern Africa. Two specimens were examined representing *S. papophoroides* and an unidentified *Schmidtia* species. Both were tetraploid but *Spies 5536* had 0–4 B chromosomes present in some cells. This confirms the basic chromosome number of 9 for the genus (De Wet & Anderson 1956; De Wet 1958), although Reeder & Singh (1968) reported on a basic chromosome number of ten.

#### Unplaced

*Centropodia* Rchb. was formerly recognized as an arundinoid genus but has recently (GPWG 2001) been included in the subfamily Chloridoideae. A single specimen of this genus was investigated and found to be octaploid ( $n = 4x = 24$ ) (Figure 13A, B). This confirms the basic chromosome number of the genus as six (Du Plessis & Spies 1988; Hoshino & Davidse 1988).

#### CONCLUSIONS

Chromosome numbers are reported for three of the five tribes of the subfamily Chloridoideae. Basic chromosome numbers of  $x = 9$  and 10 occur in all the tribes. A basic chromosome number of six is also corroborated for the genus *Centropodia*. The high incidence of polyploidy (65% in this study) in Poaceae and especially the southern African grasses are once again confirmed by this study.

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## Book Reviews

REGIONS OF FLORISTIC ENDEMISM IN SOUTHERN AFRICA. A REVIEW WITH EMPHASIS ON SUCCULENTS, by ABRAHAM E. VAN WYK & GIDEON F. SMITH. 2001. *Undaust Press*, P.O. Box 11059, 0028 Hatfield, Pretoria, South Africa. Pp. viii + 199, frontispiece + 393 colour figures, 25 distribution maps, 36 tables. Hard cover: ISBN 1-919766-18-9, price R290.00.

This is one of the exceptional botanical books published in 2001. A work of this nature has long been overdue as there is an extraordinary floristic diversity in South Africa, extending far beyond the Cape Floristic Region. Various books, symposia and workshop proceedings on the diversity of the flora and vegetation of southern Africa were published in the 1980s (Huntley 1989) and in the 1990s (Cowling & Hilton-Taylor 1994, 1997). Cowling *et al.* (1997) pinpointed hotspots of southern Africa, but this new scholarly, yet popular account, highlights the importance of floristic endemism. In his foreword to this book, Prof. Edward O. Wilson of Harvard University emphasized that 'one of the hottest spots is surely southern Africa'. The concept of hotspots as centres of plant endemism was developed by Myers (1988, 1990), and extended to southern Africa in a paper by Cowling & Hilton-Taylor (1994). This book has taken these ideas a step further and systematically treated the entire region and examined the centres of plant endemism in detail. The authors come up with 13 centres, some of which are grouped into different floristic regions such as the Succulent Karoo Region. Overall there are 19 different centres discussed in the book. To these, some 11 000 species and infra-specific taxa are assigned. Since sponsorship was provided by the Lesley Hill Succulent Karoo Trust, a greater emphasis is placed on succulent species—this amounting to some 2 300 succulents in these endemic regions.

The significance of the book lies in the descriptions of the different regions and the centres that they contain. However, before we discuss centres in detail, a review of the introduction should be given. It includes a description of the science of plant geography, definitions of vegetation, biomes and plant communities, and how the classification is used in terms of the geographical range of taxa. This leads to the definitions of centres of endemism as it has been used in the literature (White 1983) or centres of plant diversity (WWF & IUCN 1994). The authors discuss classifications of the region based on growth form and patterns of endemism and geographical range of taxa. Terms such as near-endemic, disjunct distributions, habitat continuity, floristic elements are all very clearly explained in the text. The recognition and demarcation of centres of endemism in this book is not a subjective process to which the authors applied their own ideas. Rather, they have used the wealth of data contained within the National Herbarium, Pretoria, (PRE), and the computerized data bank (PRECIS) which is available in that herbarium. They have chosen and selected centres of endemism based on perception or intuitive discernment, but have taken this further by analysing the distribution of species within these ranges. Perhaps future studies will apply a more critical objective approach, but at this level of study, the regions and centres of plant endemism appear to be sound and conform to the concepts of other authors. The map of the distribution of the principal regions of plant endemism in South Africa, is likely to become a classic in teaching and research literature.

Discussions of each floristic region and centre is covered in the same way with information on its name and history, the boundaries, topography and climate, geology and soils, vegetation and flora, (particularly succulents), including information on conservation and future research. The Cape Floristic Region, however, is not covered in great detail, but there is already a wealth of literature available on the Cape flora, so this does not distract from the value of the book. Since succulents form the main focus of the book, the Succulent Karoo Region is an important component thereof with five different centres discussed within that region. Although the Succulent Karoo is well known, these centres are discussed in some detail in this book, and the representative endemic succulents will become better known and the centres better defined as a result of this study.

The remaining centres: Maputland, Pondoland, Albany, Drakensberg-Alpine, Barberton, Wolkberg, Sekhukhuneland, Soutpansberg, Chimanimani-Nyanga, Great Dyke, Kaokoveld and Griqualand West are less known and often these are areas of great interest previously not well described. For example, the Great Dyke Centre of Zimbabwe is

shown as a dark red line on the map dividing Zimbabwe in two. Although one of the smallest and least known centres, interesting information on the distribution of plants along this geological feature, will surely emphasize the importance of geology and distribution of plants.

Some of the centres have been poorly studied, yet are under potential threat of development. For example, the Pondoland Centre is threatened with the proposed development of a toll road through the Transkei, yet, on the other hand, it may still be subject to conservation in the event that the Pondoland Coastal National Park becomes a reality. Likewise, the Sekhukhuneland Centre has been under threat of mining for platinum and iron for many years. The flora of these mountains may be lost if we do not emphasize the importance of conservation in these areas.

As an ageing ecologist I find it unfortunate that this book was not published earlier in my career. With its magnificent photographs, detailed maps of the centres and lists of species which are endemic to these regions, it would have stimulated a wider interest in the botany of southern Africa. We need to emphasize to would-be developers and the lay public in southern Africa that plants should not come second to animals in conservation, since they provide the habitat and food for the animals, as well as being conservationally important in their own right. There is still much to be learnt about the detailed evolution of these floras, the fragile links between centres, and the additional aesthetic appeal of the plants, which is of paramount interest to botanists and laymen alike.

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BULBS. Revised edition by JOHN E. BRYAN. 2002. *Timber Press*, 133 S.W. Second Ave, Suite 450, Portland, Oregon 97204-3527, USA. Pp. 524. Hard cover: ISBN 0-88192-529-2, price US\$ 89.95.

This edition provides an account of 315 bulbous plant genera, many in cultivation, illustrated by 1 128 colour photographs, some black-and-white drawings and 43 colour reproductions from *Curtis's Botanical Magazine*.

This monumental work is an extensively revised and enlarged edition of John Bryan's American Horticultural Society, award-winning first edition of *Bulbs* which was published in 1989. The North American edition now comprises one volume instead of two. The text



is in slightly larger, easier-to-read font and with some changes in formatting and layout. Text pages number 524 (previously 450), largely due to an increase in the number of genera discussed from 251 to 315. The number of pages of colour plates has increased to 374 (previously 300) with 1 171 colour photographs and reproductions (previously 832), individually numbered and referenced in Chapter 9. The text and illustrations in the first edition are retained, but wherever possible the scientific names and other information have been updated. Headings of the introductory and nine numbered chapters are unchanged in the new edition, but there has been some revision of the appendices, with the old Appendix D to J now combined into one, Appendix C. Two new appendices, B and D, are respectively bulbs around the World (previously on endpapers) and a useful conversion table for readers in metricated countries. The old Appendix B is now replaced by an index of common names, which follows the glossary and bibliography, while the old list of slide contributors, about the botanical drawings and combined index have been dispensed with altogether. It is nevertheless easy to find a plant by its scientific or common name, and that is surely essential! A feature of both editions is that authorities for scientific names are regrettably dispensed with, which decreases the book's usefulness to botanists.

Enough of comparisons. I will now review the new edition in greater detail. The first eight, brief chapters include an overview, history, botany and classification of bulbs, propagation, cultivation, bulbs in the landscape, growing bulbs out of season (i.e. 'forcing'), and pests and diseases. The final chapter, Chapter 9, comprising the bulk of the book (pp. 64–480), is an alphabetical listing of the genera. It is followed by four appendices, which are mentioned in the preceding paragraph. Finally a glossary, bibliography, and index of common names complete the book.

The book is essentially a horticultural reference work, but due to its encyclopaedic coverage of the subject, will be of great value to home gardeners, professional horticulturists and botanists alike. The author's concise but humorous writing style makes this an enjoyable read. Mr Bryan's fascination with bulbs is evident throughout: this is clearly a work of love. Additionally, his more than 50 years' experience as horticulturist, director of botanical gardens and garden tour guide both locally and internationally, have resulted in an authoritative text. As a botanist I particularly appreciated his painstaking efforts to use the correct scientific names for plants, and to explain the mysteries of plant classification and nomenclature to lay readers. The brief discussion of conservation issues (Chapter 5), in these days when virtually every plant is threatened directly by over-exploitation or indirectly by habitat destruction, is apposite.

Turning to Chapter 9, the attributes by which any particular genus qualifies for inclusion are unclear. A 'bulb' is defined (Chapter 1) as an underground storage organ (true bulb, corm, tuber, rhizome, swollen root or roots) which enables the plant to survive unfavourable climatic conditions; generally the aerial parts are deciduous. This definition includes monocotyledonous and dicotyledonous families without drawing this fundamental distinction (*Ceropegia*: Apocynaceae, is next to *Chamaelirium*: Melanthiaceae), which is surely of importance to gardeners and horticulturists. Although many are 'bulbous', orchids are specifically excluded by the author as being specialist subjects. Zingiberaceae, too, are excluded as being mostly tropical and therefore outside the bounds of this book, yet the small temperate genus *Roscoea* is to be found here, as well as the evergreen, rhizomatous *Clivia* (Amaryllidaceae). Several of the genera added in this edition are South African, and I cannot help wondering why such a genus as *Neodregea* would be included, especially since, quoting Bryan 'it is unlikely that this plant is in cultivation'. The author answers the question in his introduction where he says 'The selection ... is my choice alone ...' resulting in the astounding total of 315 genera! I did not even attempt to count the number of species, subspecies, cultivars and hybrids. Also included in the alphabetical listing are intergeneric hybrids, and so-called 'blank' entries which provide a cross reference (in the absence of a general index) to the genus where the relevant plant names are now to be found as a result of a change in classification. This practice could be misleading as in the case of *Cryptostephanus* (Amaryllidaceae)

which is only to be found as the old genus for *Cyrtanthus herrei*, whereas it is a good and horticulturally interesting tropical African genus of three species, related to *Clivia*. It appears, too, that while older name changes are mostly accepted and reasonably well explained, recent ones such as the sinking of *Homeria* (Iridaceae) into *Moraea* have been dismissed somewhat cavalierly! While on the subject of *Homeria* (now *Moraea*), it should be mentioned that several species have become serious weeds (due to their toxicity) in countries other than their native lands, primarily through garden introductions, and here would have been an opportunity for the author to caution gardeners about this problem. Another mystery is *Spiloxene* (Hypoxidaceae), the species of which are, in this new edition, returned to *Hypoxis* without explanation, a move for which I could find no grounds in recent taxonomic literature.

For each genus the family name is given, then general common names are listed, followed by several general paragraphs discussing the derivation of the name, origin of the genus, medicinal usage, horticultural attributes and so on. Genera (e.g. *Lilium*, *Tulipa*) which have contributed a vast number of important garden plants are naturally discussed in some detail, while less important genera are allocated less space. Then follows paragraphs on culture, pests and diseases, propagation, species and finally, synonyms. Incidentally the 'species' list also includes categories that are not strictly species, such as hybrids and cultivars. Following each of these names is the specific common name which is linked to the index of common names at the back of the book. Each 'species' has, where known, a date of introduction to cultivation (chiefly in Europe), a brief description, specific cultural requirements and a reference to a colour photograph or reproduction, if provided.

The book is profusely illustrated, the 1 171 colour photographs and reproductions having extensive captioning. The general standard of the colour photographs is reasonable, but some are poor, e.g. Plate 927, *Ornithogalum seileri* is out of focus, whereas the identification of some is questionable e.g. Plate 236, identified as *Blandfordia nobilis*: is this not the Madagascan weed *Bryophyllum delagoense* (Crassulaceae)? and Plate 1012 is certainly not *Scilla natalensis*: it is rather *Ledebouria revoluta*. I enjoyed seeing the reproductions of the exquisite plates from *Curtis's Botanical Magazine*, but it needs to be pointed out that the colours of the pigments have over time undergone some alteration which detracts from their usefulness for identification purposes.

The book is written primarily with Northern Hemisphere users in mind. Because genera of diverse origin are included, there is need for a mention of the differences in seasons between the hemispheres; there could be included also a brief discussion of the process by which a Southern Hemisphere bulb is adapted to the growing season in the Northern Hemisphere. Likewise the season in which the rain is received in the country of origin is of great importance and more emphasis could be placed on how winter rainfall bulbs as a group (e.g. from Western Cape, South Africa) need to be treated differently to those from summer rainfall regions (e.g. from Eastern Cape, South Africa). Because this important difference has been somewhat glossed over, some confusion may result. An example is in the treatment of *Nerine* where in Chapter 1 it states that 'Nerines, coming from a part of the world that enjoys winter rainfall ...'. However, *N. bowdenii*, one of the species discussed in Chapter 9, is quite decidedly a summer rainfall species. There is not always agreement between the plate caption and the body text, such as *Eriospermum abyssinicum* (now *E. flagelliforme*): on plate 480 it is said to be 'extremely rare' whereas in the text on p. 223 it is described as 'common' and indeed it is very common in summer rainfall South Africa and northwards in tropical Africa right up to the Central African Republic and Kenya.

Considering the scope of the book, however, these imperfections are minor ones, and this is certainly a volume I would like to have on my bookshelf.

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Parker, Ms F. B.Sc.(Hons). (SABONET contract worker)  
Paterson-Jones, Mrs D.A. (née Snijman) Ph.D. Principal  
Agricultural Scientist. Systematics of Amaryllid-  
aceae; cladistics  
Reeves, Ms G. Ph.D. Molecular systematics (contract  
worker)  
Roux, J.P. N.T.C.III(Hort.), F.L.S., Ph.D. Principal Agri-  
cultural Scientist. Systematics of Pteridophyta  
Williams, Mrs V.J. Data Capturer (SABONET contract  
worker)

## NATAL HERBARIUM—DURBAN (RHED)

Williams, Ms R. B.Sc.(Hons), H.E.D. Control Agricultural Technician. Curator

- Dimon, Ms Z.Y. B.Sc. Data Capturer (SABONET con-  
tract worker)  
Govender, Mrs N. B.Sc.(Hons) Data Capturer. *Chironia*  
systematics (SABONET contract worker)  
Hlongwane, Mrs N.C. Cleaner II & messenger  
Mbonambi, B.M. Groundsman II.  
Nathoo, Ms M. B.Sc. Data Capturer (SABONET con-  
tract worker)  
Ngwenya, A.M. Agricultural Development Technician.  
Herbarium Officer. Plant identification and infor-  
mation, Zulu Botanical Knowledge Project  
Mazibuko, J.V.G. Auxiliary Services Officer II. Herba-  
rium Assistant  
Noble, Mrs H-E. Senior Provisioning Admin. Clerk III  
Singh, Ms Y. M.Sc., H.E.D. Senior Agricultural Scien-  
tist. Taxonomy of Araceae, Hypoxidaceae

## ETHNOBOTANY UNIT—DURBAN (RETH)

Crouch, N.R. Ph.D. Assistant Director. Ethnobotany of southern African flora

## NATIONAL HERBARIUM—PRETORIA (RHEN)

Koekemoer, Ms M. Ph.D. Deputy Director. Herbarium management.  
Taxonomy of Asteraceae: Gnaphalieae

Bredenkamp, Mrs C.L. M.Sc. Principal Agricultural Scientist. Assistant Curator: Public relations.  
Taxonomy of *Vitex*, *Passerina*, Rhamnaceae, Sterculiaceae and other related families  
Herman, P.P.J. M.Sc. Principal Agricultural Scientist. Assistant Curator: Personnel. Taxonomy of  
Asteraceae, Flora of Transvaal

- Anderson, Ms H.M. Ph.D. Principal Agricultural Scien-  
tist. Palaeobotany, palaeogeography  
Anderson, J.M. Ph.D. Specialist Scientist. Palaeobotany,  
palaeogeography  
Archer, R.H. Ph.D. Senior Agricultural Scientist. Taxon-  
omy of mainly Celastraceae, Euphorbiaceae  
Archer Mrs C. M.Sc. Senior Agricultural Scientist. Taxon-  
omy of Cypraceae, Restionaceae, Orchidaceae  
Burgoyne, Ms P.M. M.Sc. Principal Agricultural Scien-  
tist. Mesembryanthemaceae  
Fish, Mrs L. B.Sc. Principal Agricultural Scientist. Taxon-  
omy of Poaceae. Plant collecting programme;  
supervising mounters  
Glen, H.F. Ph.D. Specialist Scientist. Taxonomy of trees,  
herbarium for cultivated plants, and botanical col-  
lectors  
Glen, Mrs R.P. M.Sc. Chief Agricultural Development  
Technician. Taxonomy of ferns, water plants  
Jordaan, Mrs M. M.Sc. Principal Agricultural Scientist.  
Taxonomy of Casuarinaceae—Connaraceae, *Maytenus*  
Kgaditsi, T.W. Senior Auxiliary Services Officer. Spec-  
imen mounter, general assistant in cultivated plants  
section  
Klein, R.G. Plant Collector, Bioprospecting Project (con-  
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barium Assistant. Encoding plant specimens  
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Technician. Information Officer  
Maserumule, M.K. Auxiliary Services Officer, Wing B

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- Mmakola, E.K. Data Capturer (SABONET contract worker)
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- Mothapo, M.A. Data Capturer (SABONET contract worker)
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- Naicker, K. Dip.(Bookkeeping). Sales & Marketing Management Certificate, H.Cert.(Prac. Accounting). Senior Provisioning Admin. Clerk II. Administrative support
- Netnou, Ms N.C. M.Sc. Senior Agricultural Development Technician. Wing D
- Nkoana, L.S. B.Sc. Senior Agricultural Development Technician. SABONET project
- Nkoane, Ms G.K. Auxiliary Services Officer II. Herbarium Assistant. Parcelling, pressing, general assistance
- Nkonki, Mrs T. B.Sc. Senior Agricultural Development Technician. Wing B
- Perold, Mrs S.M. Ph.D. Taxonomy of Hepaticae (contract worker)
- Phahla, T.J. Senior Auxiliary Services Officer. Specimen mounter of bryophytes and vascular plants
- Ready, Mrs J.A. N.Dip.(Hort.). Principal Auxiliary Services Officer. Herbarium Assistant. Wing D
- Rampho, Ms E.T. Data Quality Controller (SABONET contract worker) SECOSUD
- Retief, Miss E. M.Sc. Principal Agricultural Scientist. Pollen studies of Boraginaceae. Taxonomy of Boraginaceae, Verbenaceae, Lamiaceae, Asteraceae, Rubiaceae
- Sebothoma, P.N. Senior Auxiliary Services Officer II. Plant identifications co-ordinator
- Smithies, Mrs S.J. M.Sc., Dip.Ed.(Moray House). Chief Agricultural Development Technician. Taxonomy of Scrophulariaceae, Selaginaceae, Lobeliaceae
- Steyn, Ms C.C. Principal Auxiliary Services Officer. Label typist
- Van Rooy, J. Ph.D. Principal Agricultural Scientist. Taxonomy and biogeography of mosses
- Van Wyk, E. M.Sc. Agricultural Development Technician. Seedbank Manager, Kew Millennium Seedbank Project (contract worker)
- Victor, Ms J.E. M.Sc., H.Dip.(Journ.). Principal Agricultural Scientist. Taxonomy of Rutaceae, Asclepiadaceae
- Welman, Ms W.G. M.Sc. Principal Agricultural Scientist. Taxonomy of Convolvulaceae, Solanaceae, Cucurbitaceae, Campanulaceae, Asteraceae, Acanthaceae

#### DATA MANAGEMENT—PRETORIA (RPDC)

Arnold, T.H. M.Sc. Assistant Director. Computer database application especially in taxonomy

- Botha, Mrs A.G. Chief Auxiliary Services Officer. Admin. Assistant (part time)
- De Wet, Mrs B.C. B.Sc.(Computer Science), B.A., H.D.L.S. Principal Agricultural Datametrician
- Harris, Mrs B.J. Chief Auxiliary Services Officer. Encoding, quality control
- Neveling, Mrs V.H. Principal typist I
- Smit, G.C. NT Workstation 4, NT Server 4. Principal Network Controller
- Snyman, Mrs E.E. B.Sc. N.Dip.(Comp. Data Proc.) Senior Agricultural Development Technician
- Steyn, Ms H.M. Botanical Information Officer (contract worker)
- Swelankomo, N. Agricultural Development Technician. Quality control

#### SABONET

##### PRETORIA

Siebert, S.J. Ph.D. Regional Co-ordinator (contract worker)

- Haasbroek, Ms C.M. B.Com. Financial Officer (contract worker)
- Mössmer, Ms M. B.Sc.(Hons). Publications and Website Management (contract worker)
- Noko, Ms N.R. Admin. Officer (contract worker)

#### EDUCATION AND RESEARCH SUPPORT—PRETORIA (EDIR)

Wolfson, Mrs M.M. Ph.D. Deputy Director. Physiology/Ecophysiology of Poaceae, carbon uptake metabolism, allocation in response to environmental and management stress

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Potgieter, Mrs E. Principal Librarian

## EDUCATION (EDIR)

## GOLD FIELDS CENTRE—CAPE TOWN (EECT)

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## NORTHERN GARDENS (GENT/HO) AND PRETORIA (GENT/GP)

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De Bruyn, Ms A.J. B.Sc. (Zoo., Bot. & Mammalogy). Principal Communication Officer. Environmental education	Nkomo, Mrs A. Assistant Admin. Officer (contract worker) Novellie, Mrs E. H.E.D. B.Sc.(Hons) (Zool. & Mammalogy) Senior Environmental Education Officer. Environmental education
Mathaba, T.C. Environmental Education Officer	

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## RESEARCH SUPPORT SERVICES AND PUBLICATIONS—PRETORIA (RPUB)

Liebenberg, Mrs E.J.L. M.Sc. Chief Agricultural Development Technician. Cytotaxonomy. Manager

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Germishuizen, G. M.Sc. Assistant Director. Editor	Romanowski, Mrs A.J. Dip.(Photography). Chief Industrial Technician (Photography). Scientific photographer
Mapheza, T.P. Senior Provisioning Admin. Clerk III. Bookshop Manager	Turck, Mrs S. B.A.(Information Design). Senior Industrial Technician. Graphic design

## MARY GUNN LIBRARY—PRETORIA (RLBP)

Potgieter, Mrs E. B.Lib. Principal Librarian

Fourie, Mrs A. B.A., H.Dip.Lib.Sci. Principal Librarian (part time)  
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## CAPE TOWN

Rutherford, M.C. Ph.D., Dip.(Datamet.). Deputy Director: Research

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## CLIMATE CHANGE

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Kgope, B.S. M.Sc. Agricultural Scientist. Plant ecophysiology

Midgley, G.F. Ph.D. Principal Specialist Scientist. Plant ecophysiology, modelling

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Snyders, S.G. Senior Auxiliary Services Officer II. Greenhouse, maintenance

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Conservation farming. Cycad biology

Bösenberg, J. de Wet. B.Sc.(Hons). Chief Agricultural Development Technician. Cycad biology,

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## CONSERVATION FARMING PROJECT

Nänni, Ms I. B.Sc., H.E.D. Chief Agricultural Development Technician. Project Co-ordinator

Breebaart, Ms L. M.Sc.(Range and Forage Resources). Researcher. Production benefits of different grazing systems (Nama Karoo) (contract worker)

Leonhart, Ms A. N.Dip.(Nature Cons.). Research Assistant. Assessments of biodiversity and ecosystem services (contract worker)

Segers, Ms A. Senior Provisioning Admin. Clerk III (contract worker)

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## DESERTIFICATION

Petersen, Ms A. B.Sc.(Hons). Senior Agricultural Development Technician. Land use and vegetation mapping

## HORTICULTURAL RESEARCH

Brown, N.A.C. Ph.D. Specialist Scientist. Seed research

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## INFORMATION TECHNOLOGY

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Bardien-Overmeyer, Ms S. B.A.(Pharm.). Provisioning Admin. Officer. Admin. Manager

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## HARRY MOLTEO LIBRARY (RRLC)

Jagger, B.W. B.A. PG Dip.Lis. Librarian

Ovens, Dr C.S.H. Ph.D.(Inf.Sc.) Dip.Datametrics. (contract librarian)

## NBI WEBSITES (AMWS)

Reynolds, Ms P.Y. M.A.(Inf.Sc.), B.Proc., Dip.Datametrics, NBI Web Site Manager

## PUBLICATIONS BY THE STAFF

1 April 2001–31 March 2002

- ADAMS, T. & NOTTEN, A. 2001-08. *Velttheimia bracteata* Harv. ex Bak. (Hyacinthaceae). Internet 3 pp. <http://www.plantzafrica.com/planttuv/velttheimbract.htm>.
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- ARCHER, C. & KATIVU, S. 2001. The correct name in *Chlorophytum* for *Anthericum longistylum*. *Bothalia* 31: 40, 41.
- ARCHER, R.H., CARTER, S. & CONDY, G. 2001. *Euphorbia venterii*. *Flowering Plants of Africa* 57: t. 2176, 86–90.
- ARCHER, R.H., SNIJMAN, D.A. & BRUMMITT, R.K. 2001. (1478) Proposal to conserve the name *Boophone* Herbert with that spelling (Amaryllidaceae). *Taxon* 50: 569–571.
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- AUBREY, A. 2001-04. *Clivia gardenii* Hook. (Amaryllidaceae). Internet 2 pp. <http://www.plantzafrica.com/planted/cliviagarden.htm>.
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- AUBREY, A. 2001-07. *Aloe ferox* Mill. (Aloaceae). Internet 2 pp. <http://www.plantzafrica.com/plantab/aloeferox.htm>.
- AUBREY, A. 2001-08. *Clivia miniata* (Lindl.) Regel (Amaryllidaceae). Internet 3 pp. <http://www.plantzafrica.com/planted/cliviaminiata.htm>.
- AUBREY, A. 2001-09. *Acacia caffra* (Thunb.) Willd. (Fabaceae: Mimosoideae). Internet 2 pp. <http://www.plantzafrica.com/plantab/acaciacaffra.htm>.
- AUBREY, A. 2001-09. *Dombeya rotundifolia* Hochst. (Sterculiaceae). Internet 2 pp. <http://www.plantzafrica.com/planted/dombeyrotund.htm>.
- AUBREY, A. 2001-11. *Zantedeschia aethiopica* (L.) Spreng. (Araaceae). Internet 3 pp. <http://www.plantzafrica.com/plantwxyz/zantedeschiaeth.htm>.
- AUBREY, A. 2001-12. *Plumbago arriculata* Lam. (Plumbaginaceae). Internet 4 pp. <http://www.plantzafrica.com/plantnop/plumbago.htm>.
- AUBREY, A. 2002-01. *Acacia karroo* Hayne. (Fabaceae: Mimosoideae). Internet 4 pp. <http://www.plantzafrica.com/plantab/acaciakar.htm>.
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- DREWES, S.E., CROUCH, N.R., MASHIMBYE, M.J., DE LEEUW, B.M. & HORN, M.M. 2001. A phytochemical basis for the potential use of *Warburgia salutaris* (pepper-bark tree) leaves in place of bark. *South African Journal of Science* 97: 383–386.
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- DUNCAN, G.D. 2001d. Magnificent flowering bulbs at Kirstenbosch. *Cape Tourist Guide's Association*: 4, 5. (August newsletter). Email publication.
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- GERMISHUIZEN, G., COETZER, W. & CONDY, G. 2001. *Caesalpinia rostrata* (Fabaceae). *Flowering Plants of Africa* 57: t. 2173, 70–74.
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- GLEN, R. P. 2001. Review: Water plants of Namibia, an identification manual, by N.V. Clarke & E. Klaasen. *SABONET News* 6: 224.
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- GOLDBLATT, P., MANNING, J.C. & BERNHARD, P. 2001. Radiation of pollination systems in *Gladiolus* (Iridaceae: Crocoideae) in southern Africa. *Annals of the Missouri Botanical Garden* 88: 713–734.
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- GOLDING, J.S. 2001c. Red Data Lists in southern Africa. Quo vadis? *SABONET News* 6: 119–121.
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## Guide for authors to *Bothalia*

This guide is updated when necessary and includes an index. **Important points and latest additions appear in bold type.**

*Bothalia* is named in honour of General Louis Botha, first Premier and Minister of Agriculture of the Union of South Africa. This house journal of the National Botanical Institute, Pretoria, is devoted to the furtherance of botanical science. The main fields covered are taxonomy, ecology, anatomy and cytology. Two parts of the journal and an index to contents, authors and subjects are published annually.

### 1 Editorial policy

1.1 *Bothalia* welcomes original papers dealing with flora and vegetation of southern Africa and related subjects. Full-length papers and short notes, as well as book reviews and obituaries of botanists, are accepted. The editor should be notified that an article is part of a series of MSS; please submit a list of the parts of a series; all parts should preferably be published in one journal.

1.2 Submission of a manuscript to *Bothalia* implies that it has not been published previously and is not being considered for publication elsewhere.

1.3 Authors whose first language is not English are requested to have their MS edited by an English speaker before submission.

1.4 Articles are assessed by referees, both local and overseas. Authors are welcome to suggest possible referees to judge their work. Authors are responsible for the factual correctness of their contributions. *Bothalia* maintains an editorial board (see title page) to ensure that international standards are upheld.

1.5 **Page charges:** as stated in our notification included in volume 23.1 (May 1993), MSS submitted for publication in *Bothalia* are subject to payment of page charges of R125,00 per printed page, VAT included. The following are exempt from these charges: 1. NBI members; 2. persons/institutions who have been granted exemption by the Executive Committee of the NBI; 3. authors of contributions requested by the Editor; 4. contributors to the column 'FSA contributions'. The Editor's decision on the number of pages is final. An invoice will be sent to the author, who must arrange for payment as soon as possible to NBI, Publications Section, Private Bag X101, Pretoria 0001.

1.6 **Deadline dates for submission of MS: for possible inclusion of the MS for the May issue—August of the previous year, and for the October issue—March of the same year.**

### 2 Requirements for a manuscript

2.1 The original manuscript should be typed on one side of A4-size paper, double line spacing throughout (including abstract, tables, captions to figures, literature

references, etc.) and have a margin of at least 30 mm all round. Three photocopies (all pages photocopied on both sides of the paper, including figures, to reduce weight for postage) of all items, including text, line drawings, tables and lists should be submitted, and the author should retain a complete set of copies. Three photographs (or high quality photocopies) of each photograph/photograph mosaic should be submitted for review purposes. The electronic version should be submitted with the final (accepted) manuscript (see 3).

2.2 Papers should conform to the general style and layout of recent issues of *Bothalia* (from volume 26 onwards).

2.3 Material should be presented in the following sequence: Title page with title, name(s) of author(s), keywords, abstract (and information that should be placed in a footnote on the title page, such as address(es) of author(s) and mention of granting agencies).

2.4 The sequence continues with Introduction and aims, Contents (see 8), Material and methods, Results, Interpretation (Discussion), Specimens examined (in revisions and monographs), Acknowledgements, References, Index of names (recommended for revisions dealing with more than about 15 species), Tables, Captions for figures and figures. In the case of short notes, obituaries and book reviews, keywords and abstract are superfluous.

2.5 All pages must be numbered consecutively beginning with the title page to those with references, tables, captions for figures and figures.

2.6 Special characters: use your own word or code that is unique and self-explanatory, enclosed between ANGLE BRACKETS, e.g. <mu>m for µm. Please supply us with a list of the codes.

2.7 Use a non-breaking space (in MS Word—Ctrl, shift, space) to keep two elements together on the same line, e.g. 3 500.

2.8 DO NOT JUSTIFY LINES.

2.9 Do not break words, except hyphenated words.

2.10 A **hyphen** is designated as one dash, with no space between the letter and the dash, e.g. ovate-lanceolate. See also 17.6.

2.11 An **N-dash** is typed in MS Word code (alt + 0150) or as **three** hyphens with no space between the letter and the hyphen, e.g. 2- - -5 mm (typeset, it looks like this, 2–5 mm).

2.12 An **M-dash** is typed in MS Word code (alt + 0151) or as **two** hyphens with no space between the letter and the hyphen, e.g. computers- -what a blessing! (typeset, it looks like this: computers—what).

2.13 Do not use a double space anywhere between words, after commas, full stops, colons, semicolons or exclamation marks.



2.14 Use lower case x as times sign, with one space on either side of the x, e.g. 2 x 3 mm.

2.15 Use single (not double) opening and closing quotes, e.g. the so-called 'stiffy' refers to a rigid diskette.

2.16 Keys—put only three leader dots before number of taxon (with one space before and after each dot), regardless of how far or near the word is from the right margin, e.g. . . . 1. *R. ovata* (see 13.18).

### 3 Requirements for diskettes/stiffies

(text to be submitted only with final/accepted version)

#### 3.1 USE NORMAL STYLE ONLY.

3.2 Electronic files can be provided on 1.4 MB stiffie disks, Iomega zip diskettes, 640 MB optical disks for Apple Mac or on CD.

3.3 Data must be IBM compatible and written in ASCII, or in Word 97 for Windows 95/98. An rtf file is preferable because it retains the formatting.

3.4 All lines, headings, keys, etc., should start flush at the margin, therefore NO INDENTATIONS, FOOTNOTES, TABS OR STYLES of any kind.

3.5 In MS Word, italics and bold should be used where necessary.

3.6 Paragraphs and headings are delineated by a carriage return (ENTER) but **no indentation**.

**3.7 Graphics i.e. drawings, graphs or photographs: submit in a separate file, must not be included in the text.**

3.8 Image files with a bigger file size than 1MB cannot be e-mailed as the NBI has a 1MB limitation on the network's firewall at Head Office.

3.9 If any image file was originated in CorelDraw versions 3–9, please provide the image file as a CDR file (please include fonts). The conversion to TIF or other file extensions will be accommodated by the NBI (see 12.2, 12.3).

3.10 If extensive changes to image files are proposed by the editor, the author will be contacted and the specific image file will have to be re-submitted after the indicated corrections have been implemented.

**3.11 Tracked changes must not be included when submitting a MS on diskette or electronically.**

### 4 Author(s)

When there are several authors, the covering letter should indicate clearly which of them is responsible for correspondence and, if possible, telephonically available while the article is being processed. The contact address and telephone number should be mentioned if they differ from those given on the letterhead.

### 5 Title

The title should be as concise and as informative as possible. In articles dealing with taxonomy or closely related subjects, the family of the taxon under discussion

(see also 13.2) should be mentioned in brackets but author citations should be omitted from plant names (see also 13.6).

### 6 Keywords

Up to 10 keywords (or index terms) should be provided in English in alphabetical sequence. The following points should be borne in mind when selecting keywords:

6.1 Keywords should be unambiguous, internationally acceptable words and not recently coined little-known words.

6.2 They should be in a noun form and verbs should be avoided.

6.3 They should not consist of an adjective alone; adjectives should be combined with nouns.

6.4 They should not contain prepositions.

6.5 The singular form should be used for processes and properties, e.g. evaporation.

6.6 The plural form should be used for physical objects, e.g. augers.

6.7 Location (province and/or country); taxa (species, genus, family) and vegetation type (community, veld type, biome) should be used as keywords.

6.8 Keywords should be selected hierarchically where possible, e.g. both family and species should be included.

6.9 They should include terms used in the title.

6.10 They should answer the following questions:

6.10.1 What is the *active concept* in the document (activity, operation or process).

6.10.2 What is the *passive concept* or object of the active process (item on which the activity, operation or process takes place).

6.10.3 What is the means of accomplishment or how is the active concept achieved (technique, method, apparatus, operation or process).

6.10.4 What is the environment in which the active concept takes place (medium, location).

6.10.5 What are the independent (controlled) and dependent variables?

6.11 Questions 6.10.1 to 6.10.3 should preferably also be answered in the title.

### 7 Abstract

7.1 Abstracts of no more than 200 words should be provided. Abstracts are of great importance and should convey the essence of the article.

7.2 They should refer to the geographical area concerned and, in taxonomic articles, mention the number of taxa treated. They should not contain information not appearing in the article.

7.3 In articles dealing with taxonomy or closely related subjects all taxa from the rank of genus downwards should be accompanied by their author citations (see also 13.6).

7.4 Names of new taxa and new combinations should not be italicized but put in bold. If the article deals with too many taxa, only the important ones should be mentioned.

## 8 Table of contents

A table of contents should be given for all articles longer than about 60 typed pages, unless they follow the strict format of a taxonomic revision.

## 9 Acknowledgements

Acknowledgements should be kept to the minimum compatible with the requirements of courtesy. Please give all the initials of the person(s) you are thanking.

## 10 Literature references

### *In text*

10.1 Literature references in the text should be cited as follows: 'Jones & Smith (1986) stated...', or '...(Jones & Smith 1986)' or (Ellis 1988: 67) when giving a reference simply as authority for a statement. For treatment of literature references in taxonomic papers see 14.

10.2 When more than two authors are involved in the paper, use the name of the first author followed by *et al.*

10.3 When referring to more than one literature reference, they should be arranged chronologically and separated by a semicolon, e.g. (Nixon 1940; Davis 1976; Anon. 1981, 1984).

10.4 Titles of books and names of journals should preferably not be mentioned in the text. If there is good reason for doing so, they should be treated as described in 10.12 & 10.13.

10.5 Personal communications are given only in the text, not in the list of references. Please add the person's full initials to identify the person more positively, e.g. C. Boucher pers. comm.

### *In References at end of article*

10.6 References of the same author are arranged in chronological sequence.

10.7 Where two or more references by the same author are listed in succession, the author's name is repeated with every reference, except in an obituary, where the name of the deceased in the list of publications (not in the references) is replaced by an N-dash.

10.8 All publications referred to in the text, including those mentioned in full in the treatment of correct names

in taxonomic papers, but no others, and no personal communications, are listed at the end of the manuscript under the heading References.

10.9 The references are arranged alphabetically according to authors and chronologically under each author, with a, b, c, etc. added to the year, if the author has published more than one work in a year. This sequence is retained when used in the text, irrespective of the chronology.

10.10 If an author has published both on his own and as a senior author with others, the solo publications are listed first and after that, in strict alphabetical sequence, those published with one or more other authors.

10.11 Author names are typed in capitals.

10.12 Titles of journals and of books are written out in full and are italicized as follows: *Transactions of the Linnean Society of London* 5: 171–217, or *Biology and ecology of weeds*: 24.

10.13 Titles of books should be given as in *Taxonomic literature*, edn 2 by Stafleu & Cowan and names of journals as in the latest edition of *World list of scientific periodicals*.

10.14 Examples of references:

### *Collective book or Flora*

BROWN, N.E. 1909. Asclepiadaceae. In W.T. Thiselton-Dyer, *Flora capensis* 6,2: 518–1036. Reeve, London.

CUNNINGHAM, A.B. 1994. Combining skills: participatory approaches in biodiversity conservation. In B.J. Huntley, Botanical diversity in southern Africa. *Strelitzia* 1: 149–167. National Botanical Institute, Pretoria.

### *Book*

DU TOIT, A.L. 1966. *Geology of South Africa*, edn 3, S.M. Haughton (ed.). Oliver & Boyd, London.

HUTCHINSON, J. 1946. *A botanist in southern Africa*. Gawthorn, London.

### *Journal*

DAVIS, G. 1988. Description of a proteoid-restioid stand in Mesic Mountain Fynbos of the southwestern Cape and some aspects of its ecology. *Bothalia* 18: 279–287.

SMOOK, L. & GIBBS RUSSELL, G.E. 1985. Poaceae. *Memoirs of the Botanical Survey of South Africa* No. 51: 45–70.

STEBBINS, G.L. Jr 1952. Aridity as a stimulus to plant evolution. *American Naturalist* 86: 35–44.

### *In press, in preparation*

TAYLOR, H.C. in press. *A reconnaissance of the vegetation of Rooiberg State Forest*. Technical Bulletin, Department of Forestry.

VOGEL, J.C. 1982. *The age of the the Kuitse river silt terrace at Homeb. Palaeoecology of Africa* 15. In press.

WEISSER, P.J., GARLAND, J.F. & DREWS, B.K. in prep. Dune advancement 1937–1977 and preliminary vegetation succession chronology at Mlalazi Nature Reserve, Natal, South Africa. *Bothalia*.

### *Thesis*

KRUGER, F.J. 1974. *The physiography and plant communities of the Jakkalsrivier Catchment*. M.Sc. (Forestry) thesis, University of Stellenbosch.

MUNDAY, J. 1980. *The genus Monechma Hochst. (Acaulthaceae tribe Justiciae) in southern Africa*. M.Sc. thesis, University of the Witwatersrand, Johannesburg.

*Miscellaneous paper, report, unpublished article, technical note, congress proceedings*

ANON. no date. *Eetbare plante van die Wolkberg*. Botanical Research Unit, Grahamstown. Unpublished.

BAWDEN, M.G. & CARROL, D.M. 1968. *The land resources of Lesotho*. Land Resources Study No. 3, Land Resources Division, Directorate of Overseas Surveys, Tolworth.

BOUCHER, C. 1981. Contributions of the Botanical Research Institute. In A.E.F. Heydom, *Proceedings of workshop research in Cape estuaries*: 105–107. National Research Institute for Oceanology, CSIR, Stellenbosch.

NATIONAL BUILDING RESEARCH INSTITUTE 1959. *Report of the committee on the protection of building timbers in South Africa against termites, woodboring beetles and fungi*, edn 2. CSIR Research Report No. 169.

## 11 Tables (also digital submissions)

11.1 Each table should be presented on a separate sheet and be assigned an Arabic numeral, i.e. the first table mentioned in the text is marked 'Table 1'.

11.2 In the captions of tables the word 'TABLE' is written in capital letters. See recent numbers of *Bothalia* for the format required.

11.3 Avoid vertical lines, if at all possible. Tables can often be reduced in width by interchanging primary horizontal and vertical heads.

## 12 Figures (also digital submissions)

12.1 Figures should be planned to fit, after reduction, into a width of either 80, 118 or 165 mm, with a maximum vertical length of 230 mm. Allow space for the caption in the case of figures that will occupy a whole page.

12.2 **Line drawings, including graphs and diagrams, should be the same size as it will appear in the journal, if appropriate, and should be in jet-black Indian ink, preferably on fine Schoellers Hammer Parole or similar paper, 200 gsm, or tracing film. Lines should be bold enough and letters/ symbols large enough to stand reduction. If submitted electronically, provide each drawing as a separate TIF, BMP or JPG file at 600 dots per inch (dpi) and a hard copy of the figure.**

12.3 **Photographs should be of excellent quality on glossy paper with clear detail, moderate contrast and clear lettering, and they should be the same size as required in the journal. If submitted electronically, provide as a TIF, BMP or JPG file at 300 dpi and not as a doc file. Include a hard copy of good quality.**

12.4 Photograph mosaics should be submitted complete, the component photographs mounted neatly on a white flexible card base (can be curved around drum of scanner) leaving a narrow gap of uniform width (2 mm) between each print. Note that grouping photographs of markedly divergent contrast results in poor reproductions.

12.5 Lettering on photograph mosaics, in capital letters, should be put on a small white disk  $\pm 7$  mm in diameter, if the background is dark, and placed in the lower left hand corner of the relevant photo.

12.6 If several illustrations are treated as components of a single composite figure they should be designated by capital letters.

12.7 Note that the word 'Figure' should be written out in full, both in the text and the captions and should begin with a capital 'F' (but see 14.7 for taxonomic papers).

12.8 In the text the figure reference is then written as in the following example: 'The stamens (Figure 4A, B) are...'

12.9 In captions, 'FIGURE' is written in capital letters. Magnification of figures should be given for the size as submitted.

12.10 Scale bars or scale lines should be used on figures.

12.11 In figures accompanying taxonomic papers, voucher specimens should be given in the relevant caption.

12.12 Figures are numbered consecutively with Arabic numerals in the order they are referred to in the text. These numbers, as well as the author's name and an indication of the top of the figure, must be written in soft pencil on the back of all figures.

12.13 Captions of figures must not be pasted under the photograph or drawing and must also not be included in any electronic version.

12.14 Authors should indicate in pencil in the text where they would like the figures to appear.

12.15 Authors wishing to have the originals of figures returned must inform the editor in the original covering letter and must mark each original 'To be returned to author'.

12.16 Authors wishing to use illustrations already published elsewhere must obtain written permission before submitting the manuscript and inform the editor of this fact.

12.17 Captions for figures should be collected together and typed at the end of the MS and headed *Captions for figures*.

12.18 It is strongly recommended that taxonomic articles include dot maps as figures to show the distribution of taxa. The dots used must be large enough to stand reduction to 80 mm (recommended size: 5 mm diameter).

12.19 Blank distribution maps of southern Africa, Africa and the world are available from the Bookshop, NBI Pretoria.

12.20 A dot map PC programme for distribution of taxa in South Africa, called MAPPIT is available for purchase from the Data Section, National Botanical Institute, Pretoria.

12.21 **ArcView GIS maps are acceptable. The layout representing all the appropriate themes (including gridlines) should be exported as a PostScript New (EPS) file at 600 dpi.**



**12.22 Colour figures are permitted only if a) it will clarify the article and b) the cost of reproduction and printing is borne by the author.**

### 13 Text

13.1 As a rule, authors should use the plant names (but not of all authors of plant names—see 13.6) as listed in PRECIS (National Herbarium PREtoria Computerised Information System).

13.2 Names of genera and infrageneric taxa are usually italicized, with the author citation (where relevant; see 13.6) not italicized. Exceptions include names of new taxa in the abstract, correct names given in the synopsis or in paragraphs on species excluded from a given supraspecific group in taxonomic articles; in checklists and in indices, where the position is reversed, correct names are not italicized and synonyms are italicized.

13.3 Names above generic level are not italicized.

13.4 In articles dealing with taxonomy, the complete scientific name of a plant (with author citation) should be given at the first mention in the text. The generic name should be abbreviated to the initial thereafter, except where intervening references to other genera with the same initial could cause confusion (see 16.6).

13.5 In normal text, Latin words are italicized, but in the synopsis of a species, Latin words such as *nom. nud.* and *et al.* are not italicized (see 14.3, 16.4, 17.9).

13.6 In accordance with Garnock-Jones & Webb (1996) in *Taxon* 45: 285, 286, authors of plant names are not to be added to plant names except in taxonomic papers. Names of authors of plant names should agree with the list published by the Royal Botanic Gardens, Kew, entitled, *Authors of plant names*, edited by R.K. Brummitt & C.E. Powell (1992).

13.7 Modern authors not included in the list should use their full name and initials when publishing new plant names. Other author names not in the list should be in agreement with the recommendations of the Code.

13.8 Names of authors of publications are written out in full, without initials, except in the synonymy in taxonomic articles where they are treated like names of authors of plant names.

13.9 Names of plant collectors are italicized whenever they are linked to the number of a specimen. The collection number is also italicized, e.g. *Acoccks 14407*.

13.10 Surnames beginning with 'De', 'Du' or 'Van' begin with a capital letter unless preceded by an initial.

13.11 For measurements use only units of the International System of Units (SI). In taxonomic papers only mm and m, should be used; in ecological papers cm or m should be used.

13.12 The use of '±' is preferred to c. or ca (see 17.7).

13.13 Numbers 'one' to 'nine' are spelt out in normal text, and from 10 onwards they are written in Arabic numerals.

13.14 In descriptions of plants, numerals are used throughout. Write 2.0–4.5 (not 2–4.5). When counting members write 2 or 3 (not 2–3), but 2–4.

13.15 Abbreviations should be used sparingly but consistently. No full stops are placed after abbreviations ending with the last letter of the full word (e.g. edition = edn; editor = ed.); after units of measure; after compass directions; after herbarium designations; after countries, e.g. USA and after well-known institutions, e.g. CSIR.

13.16 Apart from multi-access keys, indented keys should be used with couplets numbered 1a–1b, 2a–2b, etc. (without full stops thereafter).

13.17 Keys consisting of a single couplet have no numbering.

13.18 Manuscripts of keys should be presented as in the following example:

1a Leaves closely arranged on an elongated stem; a submerged aquatic with only the capitula exserted . . . 1b. *E. setaceum* var. *pumilum*

1b Leaves in basal rosettes; stems suppressed; small marsh plants, ruderals or rarely aquatics:

2a Annuals, small, fast-growing pioneers, dying when the habitat dries up; capitula without coarse white setae; receptacles cylindrical:

3a Anthers white . . . 2. *E. cinereum*

3b Anthers black . . . 3. *E. nigrum*

2b Perennials, more robust plants; capitula sparsely to densely covered with short setae:

13.19 Herbarium voucher specimens should be referred to wherever possible, not only in taxonomic articles.

### 14 Species treatment in taxonomic papers

14.1 The procedure to be followed is illustrated in the example (17.9), which should be referred to, because not all steps are described in full detail.

14.2 The correct name (bold, not italicized) is to be followed by its author citation (italicized) and the full literature reference, with the name of the publication written out in full (not italicized).

14.3 Thereafter all literature references, including those of the synonyms, should only reflect author, page and year of publication, e.g. C.E.Hubb. in Kew Bulletin 15: 307 (1960); Boris et al.: 14 (1966); Boris: 89 (1967); Sims: t. 38 (1977); Sims: 67 (1980).

14.4 The description and the discussion should consist of paragraphs commencing, where possible, with italicized leader words such as *flowering time*, *etymology*, *diagnostic characters*, *distribution* and *habitat*.

14.5 When more than one species of a given genus is dealt with in a paper, the correct name of each species should be

prefixed by a sequential number followed by a full stop. Intraspecific taxa are marked with small letters, e.g. 1b., 12c., etc.

14.6 Names of authors are written as in 13.6, irrespective of whether the person in question is cited as the author of a plant name or of a publication.

14.7 The word 'figure' is written as 'fig.', and 't.' is used for both 'plate' and 'tablet' (but see 12.7 for normal text).

14.8 Literature references providing good illustrations of the species in question may be cited in a paragraph commencing with the word **Illustrations** followed by a colon. This paragraph is given after the last paragraph of the synonymy, see 17.9.

14.9 When new combinations are made, the full literature reference must be given for the basionym, e.g.:

**Antimima saturata** (L.Bolus) H.E.K. Hartmann, comb. nov.

*Ruschia saturata* L.Bolus in Notes on Mesembrianthemum and allied genera, part 2: 122 (1929). *Mesembryanthemum atrocinctum* N.E.Br.: 32 (1930). Type: *Pillans BOL18952* (BOL, holo.).

## 15 Citation of specimens

15.1 Type specimen in synopsis: the following should be given (if available): country (if not in RSA), province, grid reference (at least for new taxa), locality as given by original collector, modern equivalent of collecting locality in square brackets (if relevant, e.g. Port Natal [now Durban]), quarter-degree square, date of collection (optional), collector's name and collecting number (both italicized).

15.2 The abbreviation s.n. (*sine numero*) is given after the name of a collector who usually assigned numbers to his collections but did not do so in the specimen in question (see 15.11), or the herbarium number can then be cited with no space between the herbarium and its number e.g. *Marloth SAM691* (see 17.9). The herbaria in which the relevant type(s) are housed are indicated by means of the abbreviations given in the latest edition of *Index Herbariorum*.

15.3 The holotype (holo.) and its location are mentioned first, followed by a semicolon, the other herbaria are arranged alphabetically, separated by commas.

15.4 Authors should indicate by means of an exclamation mark (!) which of the types have been personally examined.

15.5 If only a photograph or microfiche was seen, write as follows: *Anon.* 422 (X, holo.—BOL, photo!).

15.6 Lectotypes or neotypes should be chosen for correct names without a holotype. It is not necessary to lectotypify synonyms.

15.7 When a lectotype or a neotype are newly chosen, this should be indicated by using the phrase 'here designated' (see 17.9). If reference is made to a previously selected lectotype or neotype, the name of the designating author and the literature reference should be given. In cases where no type was cited, and none has subsequently been nominated, this may be stated as 'not designated'.

15.8 In brief papers mentioning only a few species and a few cited specimens the specimens should be arranged

according to the grid reference system: Provinces/countries (typed in capitals) should be cited in the following order: Namibia, Botswana, **Limpopo** (previously **Northern Transvaal**, **Northern Province**), North-West (previously northeastern Cape and southwestern Transvaal), Gauteng (previously PWV), Mpumalanga (previously Eastern Transvaal), Free State (previously Orange Free State), Swaziland, KwaZulu-Natal (previously Natal), Lesotho, and Northern Cape, Western Cape and Eastern Cape (Figure 1).

15.9 Grid references should be cited in numerical sequence.

15.10 Locality records for specimens should preferably be given to within a quarter-degree square. Records from the same one-degree square are given in alphabetical order, i.e. (—AC) precedes (—AD), etc. Records from the same quarter-degree square are arranged alphabetically according to the collectors' names; the quarter-degree references must be repeated for each specimen cited.

15.11 The relevant international code of the herbaria in which a collection was seen should be given in brackets after the collection number; the codes are separated by commas. The following example will explain the procedure:

KWAZULU-NATAL.—2731 (Louwsburg): 16 km E of Nongoma, (—DD), *Pelser* 354 (BM, K, PRE); near Dwaarsrand, *Vau der Merwe* 4789 (BOL, M), 2829 (Harrismith); near Groothoek, (—AB), *Smith* 234; Koffiefontein, (—AB), *Taylor* 720 (PRE); Cathedral Peak Forest Station, (—CC), *Marriot* s.n. (KMG); Wilgerfontein, *Roux* 426. Grid ref. unknown: Sterkstroom, *Strydom* 12 (NBG).

15.12 For records from outside southern Africa authors should use degree squares without names, e.g.:

KENYA.—0136: Nairobi plains beyond race course, *Napier* 485.

15.13 Monographs and revisions: in the case of all major works of this nature it is assumed that the author has investigated the relevant material in all major herbaria and that he has provided the specimens seen with determinavit labels. It is assumed further that the author has submitted distribution maps for all relevant taxa and that the distribution has been described briefly in words in the text. Under the heading 'Vouchers' no more than five specimens should be cited, indicating merely the collector and the collector's number (both italicized). Specimens are alphabetically arranged according to collector's name. If more than one specimen by the same collector is cited, they are arranged numerically and separated by a comma. The purpose of the cited specimens is not to indicate distribution but to convey the author's concept of the taxon in question.

15.14 The herbaria in which the specimens are housed are indicated by means of the abbreviation given in the latest edition of *Index Herbariorum*. They are given between brackets, arranged alphabetically and separated by commas behind every specimen as in the following example:

Vouchers: *Arnold* 64 (PRE); *Fisher* 840 (NH, NU, PRE); *Flanagan* 831 (GRA, PRE), 840 (NH, PRE); *Marloth* 4926 (PRE, STE); *Schulpe* 6161, 6163, 6405 (BOL); *Schlechter* 4451 (BM, BOL, GRA, K, PRE).

15.15 If long lists of specimens are given, they must be listed together before Acknowledgements under the heading *Specimens examined*. They are arranged alphabetically by the collector's name and then numerically for each collector. The species is indicated in brackets by the number that was assigned to it in the text and any infraspecific taxa

by a small letter. If more than one genus is dealt with in a given article, the first species of the first genus mentioned is indicated as 1.1. This is followed by the international herbarium designation. Note that the name of the collector and the collection number are italicized:

*Acocks 12497* (2.1b) BM, K, PRE; 14724 (1.13a) BOL., K, P. *Archer 1507* (1.4) BM, G. *Burchell 2847* (2.8c) MB, K. *Burman 2401* (3.3) MO, S. B. L. *Burr 789* (2.6) B. KMG. STE.

## 16 Synonyms

16.1 In a monograph or a revision covering all of southern Africa, all synonyms based on types of southern African origin, or used in southern African literature, should be included.

16.2 Illegitimate names are designated by *nom. illeg.* after the reference, followed by *non* with the author and date, if there is an earlier homonym.

16.3 *Nomina nuda* (*nom. nud.*) and invalidly published names are excluded unless there is a special reason to cite them, for example if they have been used in prominent publications.

16.4 In normal text, Latin words are italicized, but in the synopsis of a species Latin words such as *nom. nud.*, *et al.* are not italicized (see 13.5, 14.3, 17.9).

16.5 Synonyms should be arranged chronologically into groups of nomenclatural synonyms, i.e. synonyms based on the same type, and the groups should be arranged chronologically by basionyms, except for the basionym of the correct name which is dealt with in the paragraph directly after that of the correct name.

16.6 When a generic name is repeated in a given synonymy it should be abbreviated to the initial, except where intervening references to other genera with the same initial could cause confusion (see 13.4).

## 17 Description and example of species treatment

17.1 Descriptions of all taxa of higher plants should, where possible, follow the sequence: Habit; sexuality; underground parts (if relevant). *Indumentum* (if it can be easily described for the whole plant). *Stems/branches*. *Bark*. *Leaves*: arrangement, petiole absent/present, pubescence; blade: shape, size, apex, base, margin; midrib: above/below, texture, colour; petiole; stipules. *Inflorescence*: type, shape, position; bracts/bracteoles, involucre bracts: inner, outer. *Flowers*: shape, sex. *Receptacle*. *Calyx*. *Corolla*. *Disc*. *Androecium*. *Gynoecium*. *Fruit*. *Seeds*. *Flowering time*. *Chromosome number* (reference). *Conservation status*. Figure (word written out in full) number.

17.2 As a rule, shape should be given before measurements.

17.3 In general, if an organ has more than one of the parts being described, use the plural, otherwise use the singular, for example, petals of a flower but blade of a leaf.

17.4 Language must be as concise as possible, using participles instead of verbs.

17.5 Dimension ranges should be cited as in 17.9.

17.6 Care must be exercised in the use of dashes and hyphens. A *hyphen* is a short stroke joining two syllables of a word, e.g. ovate-lanceolate or sea-green, with no space between the letter and the stroke. An *N-dash* (*en*) is a longer stroke commonly used instead of the word 'to' between numerals, '2–5 mm long' (do not use it between words but rather use the word 'to', e.g. 'ovate to lanceolate'; it is produced by typing three hyphens next to each other, or in MS Word the code is alt + 0150. An *M-dash* (*em*) is a stroke longer than an N-dash and is used variously, e.g. in front of a subspecific epithet instead of the full species name; it is produced by typing two hyphens next to one another, or in MS Word the code is alt + 0151.

17.7 The use of '±' is preferred to c. or ca when describing shape, measurements, dimensions, etc. (see 13.12).

17.8 The decimal point replaces the comma in all units of measurement, e.g. leaves 1.0–1.5 mm long.

17.9 Example:

1. *Englerophytum magalismontanum* (Sond.) T.D.Penn. The genera of Sapotaceae: 252 (1991). Type: Gauteng, Magaliesberg, *Zeyher 1849* (S, holo.–BOL, photo.).

*Bequaertiodendron magalismontanum* (Sond.) Heine & Hemsl.: 307 (1960); Codd: 72 (1964); Elsdon: 75 (1980).

*Chrysophyllum magalismontanum* Sond.: 721 (1850); Harv.: 812 (1867); Engl.: 434 (1904); Bottmar: 34 (1919). *Zeyherella magalismontana* (Sond.) Aubrév. & Pellegr.: 105 (1958); Justin: 97 (1973).

*Chrysophyllum argyrophyllum* Hiern: 721 (1850); Engl.: 43 (1904). *Boivinella argyrophylla* (Hiern) Aubrév. & Pellegr.: 37 (1958); Justin et al.: 98 (1973). Types: Angola, *Welwitsch 4828* (BM!, lecto., here designated; PRE!); Angola, *Welwitsch s.n.* (BM!).

*Chrysophyllum wilmsii* Engl.: 4, t. 16 (1904); Masonet: 77 (1923); Woodson: 244 (1937). *Boivinella wilmsii* (Engl.) Aubrév. & Pellegr.: 39 (1958); Justin: 99 (1973). Type: *without locality and collector* [B, holo.?, K!, P!, lecto., designated by Aubrév. & Pellegr.: 38 (1958), PRE!, S!, W!, Z!].

*Bequaertiodendron fruticosa* De Wild.: 37 (1923), non Bonpl.: 590 (1823); D.Bakker: 167 (1929); H.Fr.: 302 (1938); Davy: 640 (1954); Breytenbach: 117 (1959); Clausen: 720 (1968); Palmer: 34 (1969). Type: Mpumalanga, Tzaneen Dist., *Granville in Herb. Pillans K48625* (K, holo.!, G!, P!, PRE!, S!).

*B. fragrans* auct. non Oldemann: Glover: 149, t. 19 (1915); Henkel: 226 (1934); Stapleton: 6 (1954).

Illustrations: Harv.: 812 (1867); Henkel: t. 84 (1934?); Codd: 73 (1964); Palmer: 35 (1969).

Woody perennial; main branches up to 0.4 m long, erect or decumbent, grey woolly-felted, leafy. *Leaves* linear to oblanceolate, 3–10(–23) × 1.0–1.5(–4.0) mm, obtuse, base broad, half-clasping. *Heads* heterogamous, campanulate, 7–8 × 5 mm, solitary, sessile at tip of axillary shoots; involucre bracts in 5 or 6 series, inner exceeding flowers, tips subopaque, white, very acute. *Receptacle* nearly smooth. *Flowers* ± 23–30, 7–11 male, 16–21 bisexual, yellow, tipped pink. *Achenes* ± 0.75 mm long, elliptic. *Pappus* bristles very many, equalling corolla, scabridulous. *Flowering time*: September. *Chromosome number*: 2n = 22. Figure 23B.



## 18 New taxa

18.1 The name of a new taxon must be accompanied by at least a Latin diagnosis. Authors should not provide full-length Latin descriptions unless they have the required expertise in Latin at their disposal.

18.2 It is recommended that descriptions of new taxa be accompanied by a good illustration (line drawing or photograph) and a distribution map.

18.3 Example:

109. *Helichrysum jubilatum* Hilliard, sp. nov., *H. alsinoidei* DC. affinis, sed foliis ellipticis (nec spatulatis), inflorescentiis compositis a foliis non circumcinctis, floribus femineis numero quasi dimidium hermaphroditorum aequantibus (nec capitulis homogamis vel floribus femineis 1–3 tantum) distinguitur.

Herba annua e basi ramosa; caules erecti vel decumbentes, 100–250 mm longi, tenuiter albo-lanati, remote foliati. *Folia* plerumque 8–30 × 5–15 mm, sub capitulis minora, elliptica vel oblanceolata, obtusa vel acuta, mucronata, basi semi-amplexicauli, utrinque cano-lanato-arachnoidea. *Capitula* heterogama, campanulata, 3.5–4.0 × 2.5 mm, pro parte maxima in paniculas cymosas terminales aggregata; capitula subterminalia interdum solitaria vel 2 vel 3 ad apices ramulorum nudorum ad 30 mm longorum. *Bractae involucales* 5-seriatae, gradatae, exteriores pellucidae, pallide stramineae, dorso lanatae, seriebus duabus interioribus subaequalibus et flores quasi aequantibus, apicibus obtusis opacis niveis vix radiantibus. *Receptaculum* fere laeve. *Flores* ± 35–41. *Achenia* 0.75 mm longa, pilis myxogenis praedita. *Pappi* setae multae, corollam aequantes, apicibus scabridis, basibus non cohaerentibus.

TYPE.—Northern Cape, 2817 (Vioolsdrif): Richtersveld, (–CC), ± 5 miles E of Lekkering on road to Stinkfontein, kloof in hill south of road, annual, disc whitish, 7-11-1962, *Nordenstam* 1823 (S, holo.; E, NH, PRE).

## 19 New provinces of South Africa (Oct. 1996)

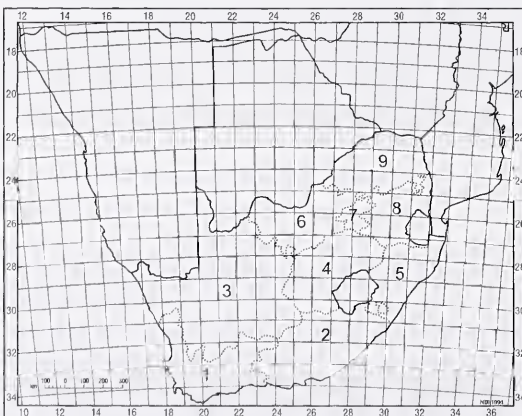


FIGURE 1.—1, Western Cape; 2, Eastern Cape; 3, Northern Cape; 4, Free State (previously Orange Free State); 5, KwaZulu-Natal (previously Natal); 6, North-West (previously northeastern Cape and southwestern Transvaal); 7, Gauteng (previously PWV); 8, Mpumalanga (previously Eastern Transvaal); 9, Limpopo (previously Northern Transvaal, Northern Province).

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## 21 Reprints

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## 22 Documents consulted

Guides to authors of the following publications were made use of in the compilation of the present guide: *Annals of the Missouri Botanic Garden*, *Botanical Journal of the Linnean Society*, *Flora of Australia*, *Smithsonian Contributions to Botany*, *South African Journal of Botany* (including instructions to authors of taxonomic papers), *South African Journal of Science*.

## 23 Address of editor

Manuscripts should be submitted to: The Editor, Bothalia, National Botanical Institute, Private Bag X101, Pretoria 0001.

## 24 FSA contributions

24.1 Figures and text must conform to *Bothalia* format.

24.2 These articles will be considered as a full contribution to the *Flora of southern Africa* and will be listed as published in the 'Plan of Flora of southern Africa', which appears in all issues of the FSA series.

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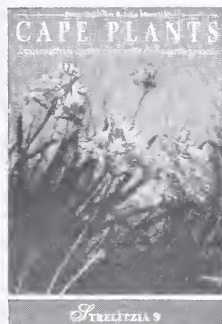


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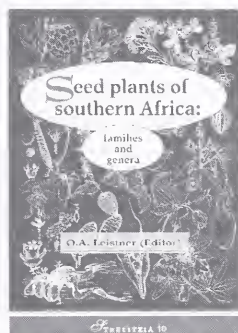
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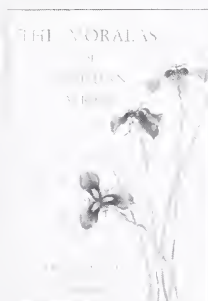
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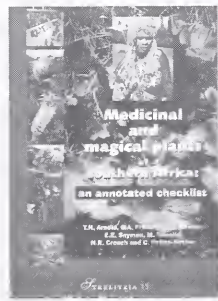
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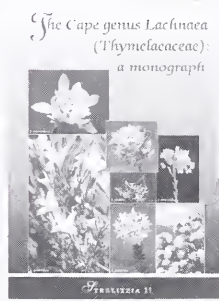


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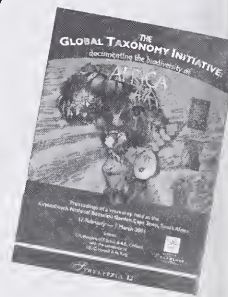
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